

ESL-TR-82-41

③

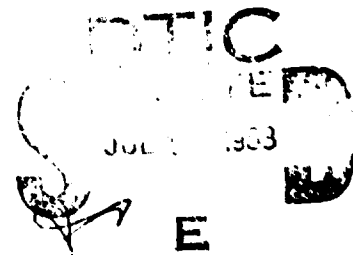
THE EFFECTS OF WEATHER ON RAPID RUNWAY REPAIR (VOLUME II OF II)

WHITEHEAD, J.M., HOFFMAN, M.D., POTTER, P.E.,
NEUSWANGER, C.P., WILDING, M.M.

THE BDM CORPORATION
7915 JONES BRANCH DRIVE
McLEAN VA. 22102

MAY 1983

FINAL REPORT
30 JUN 1982 - 5 NOV 1982



APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED



ENGINEERING & SERVICES LABORATORY
AIR FORCE ENGINEERING & SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403

88 07 14 056

Best Available Copy

ADA 130350

UNC FILE COPY

NOTICE

PLEASE DO NOT REQUEST COPIES OF THIS REPORT FROM
HQ AFESC/RD (ENGINEERING AND SERVICES LABORATORY).
ADDITIONAL COPIES MAY BE PURCHASED FROM:

NATIONAL TECHNICAL INFORMATION SERVICE
5285 PORT ROYAL ROAD
SPRINGFIELD, VIRGINIA 22161

FEDERAL GOVERNMENT AGENCIES AND THEIR CONTRACTORS
REGISTERED WITH DEFENSE TECHNICAL INFORMATION CENTER
SHOULD DIRECT REQUESTS FOR COPIES OF THIS REPORT TO:

DEFENSE TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VIRGINIA 22314

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ESL-TR-82-41	2. GOVT ACCESSION NO. AD-1130350	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) The Effects of Weather on Rapid Runway Repair (Volume II of II)		5. TYPE OF REPORT & PERIOD COVERED Final Report 30 Jun 82 - 5 Nov 82
		6. PERFORMING ORG. REPORT NUMBER BDM/W-82-592-TR
7. AUTHOR(s) WHITHEAD, J M. HOFFMAN, M D, Potter, P G, Neuswanger, J P, Wilding, M M.		8. CONTRACT OR GRANT NUMBER(s) F08635-80-C-0206
9. PERFORMING ORGANIZATION NAME AND ADDRESS The BDM Corp 7915 Jones Branch Drive McLean VA 22102		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS JON 26211008 PE 64708F
11. CONTROLLING OFFICE NAME AND ADDRESS Engineering and Services Laboratory (RDCR) Air Force Engineering and Services Center Tyndall AFB FL 32403		12. REPORT DATE May 1983
		13. NUMBER OF PAGES 315
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Distribution Unlimited: Approved for Public Release		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Availability of this report is specified on reverse of Front Cover.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Rapid Runway Repair Bomb Damage Repair Weather Effects		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This technical report is divided into two volumes. Volume I contains the technical analysis and weather effects on RRR process, while Appendix A, weather Data, is published as Volume II because of its size. This report presents the results of a study to identify the effects of weather on Rapid Runway Repair (RRR). There are two major components of the study. The first characterizes the aspects of weather that affect RRR, by area for Korea, Europe, and England. Graphs present data on		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

temperature, precipitation, visibility, wind, and humidity. The second component studies the effects of weather on the RRR process. The process is divided into activities, with associated efficiencies under various weather conditions. Values for the efficiencies are developed from military and industrial data. The two components are combined with a critical path analysis of several RRR procedures. The report identifies potential solutions to some weather related problems, and makes recommendations for further study.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

PREFACE

This report was prepared by the BDM Corporation, 7915 Jones Branch Drive, McLean, Virginia 22102, under Contract F08635-80-C-0206 with the Air Force Engineering and Services Center, Engineering and Service Laboratory (AFESC/RD), Tyndall Air Force Base, Florida.

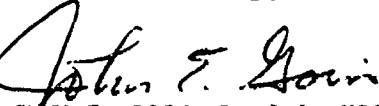
The work was accomplished during the period beginning 30 June 1982 and ending 5 November 1982. The work was performed at the BDM Corporation.

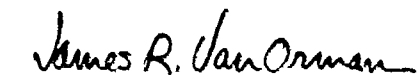
AFESC/RDCR project officer was 2nd Lt James A. Kirkland.


This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.


JAMES A. KIRKLAND
Postattack Research Engineer


JOHN E. GOIN, Lt Col, USAF
Chief, Engineering Research Division


JAMES R. VAN ORMAN, GM-14
Chief, Rapid Runway Repair Branch


FRANCIS B. CROWLEY, III, Colonel, USAF
Director, Engineering and Services Laboratory

Accession For	
NTIS GRAM	X
DTIC TAB	
Unannounced	
Justification	
By	
Distribution	
Availability Codes	
Avail and/or	
Dist	Special
A	



TABLE OF CONTENTS

Appendix	Title	Page
A	WEATHER DATA	1
1.	Temperature.....	3
a.	Monthly Temperature Ranges.....	3
b.	Daily Minimum/Mean/Maximum Temperature Ranges.....	9
c.	Frequency of Occurrence of Indicated Temperatures.....	25
d.	Duration of Extreme Temperatures.....	62
2.	Precipitation.....	84
a.	Estimates for a 2-Year 1-Hour Rainfall.....	85
b.	Maximum Amounts of Daily Precipitation/Snowfall/Snowdepth.....	87
c.	Daily Amounts of Precipitation/ Snowfall/Snowdepth.....	102
d.	Frequency of Occurrence of Weather Conditions.....	171
e.	Maximum Amounts of Precipitation.....	177
f.	Duration of Precipitation.....	179
3.	Visibility.....	216
a.	Frequency of Occurrence of Indicated Visibilities: ≤ 1/4, 5/16, 1/2 mile.....	217
b.	Duration of Visibility ≤ 900 feet.....	221
c.	Frequency of Occurrence of Indicated Visibilities: V < 400, 300, 200, 100 meters.....	229
4.	Wind and Wind Chill.....	234
a.	Daily Peak Gusts.....	235
b.	Ninety-Ninth Percentile Wind Chill Temperatures.....	241
c.	Frequency of Occurrence of Wind Speeds.....	243

TABLE OF CONTENTS (CONCLUDED)

Appendix	Title	Page
5.	Relative Humidity.....	283
a.	Mean Relative Humidity.....	284
b.	Ranges of Relative Humidity.....	288
	REFERENCES.....	292

LIST OF FIGURES

Figure	Title	Page
A-1	Monthly Temperature Ranges, Upper Heyford.....	4
A-2	Monthly Temperature Ranges, Mean of German Airbases.....	5
A-3	Monthly Temperature Ranges, Korea: Mean of Osan and Kunsan.....	6
A-4	Monthly Temperature Ranges, Worst Case: Germany.	7
A-5	Monthly Temperature Ranges, Worst Case: Korea...	8
A-6	Daily Minimum Temperature Range, Upper Heyford...	10
A-7	Daily Mean Temperature Range, Upper Heyford.....	11
A-8	Daily Maximum Temperature Range, Upper Heyford...	12
A-9	Daily Minimum Temperature Range, Mean of German Airbases.....	13
A-10	Daily Mean Temperature Range, Mean of German Airbases.....	14
A-11	Daily Maximum Temperature Range, Mean of German Airbases.....	15
A-12	Daily Minimum Temperature Range, Korea: Mean of Osan and Kunsan.....	16
A-13	Daily Mean Temperature Range, Korea: Mean of Osan and Kunsan.....	17
A-14	Daily Maximum Temperature Range, Korea: Mean of Osan and Kunsan.....	18
A-15	Daily Minimum Temperature Range, Worst Case: Germany.....	19
A-16	Daily Mean Temperature Range, Worst Case: Germany.....	20
A-17	Daily Maximum Temperature Range, Worst Case: Germany.....	21

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-18	Daily Minimum Temperature Range, Worst Case: Korea.....	22
A-19	Daily Mean Temperature Range, Worst Case: Korea.....	23
A-20	Daily Maximum Temperature Range, Worst Case: Korea.....	24
A-21	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	26
A-22	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	27
A-23	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	28
A-24	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	29
A-25	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	30
A-26	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	31
A-27	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	32
A-28	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	33
A-29	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	34
A-30	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	35
A-31	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	36
A-32	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.....	37

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-33	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	38
A-34	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	39
A-35	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	40
A-36	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	41
A-37	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	42
A-38	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	43
A-39	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	44
A-40	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	45
A-41	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	46
A-42	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	47
A-43	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	48
A-44	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.....	49
A-45	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of German Airbases.....	50
A-46	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of German Airbases.....	51
A-47	Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of German Airbases.....	52

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-48	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	53
A-49	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	54
A-50	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	55
A-51	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	56
A-52	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	57
A-53	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	58
A-54	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	59
A-55	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	60
A-56	Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.....	61
A-57	Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - January.....	63
A-58	Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - February.....	64
A-59	Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - November.....	65
A-60	Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - December.....	66
A-61	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - January.....	67
A-62	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - February.....	68

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-63	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - March.....	69
A-64	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - November.....	70
A-65	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - December.....	71
A-66	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - January.....	72
A-67	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - February.....	73
A-68	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - March.....	74
A-69	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - November.....	75
A-70	Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - December.....	76
A-71	Duration of Indicated Temperatures, Worst Case in Germany: Ramstein AFB - June.....	77
A-72	Duration of Indicated Temperatures, Worst Case in Germany: Ramstein AFB - July.....	78
A-73	Duration of Indicated Temperatures, Worst Case in Germany: Ramstein AFB - August....	79
A-74	Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - June.....	80
A-75	Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - July.....	81
A-76	Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - August.....	82
A-77	Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - September.....	83

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-78	Maximum Amounts of Daily Precipitation, Upper Heyford.....	88
A-79	Maximum Amounts of Daily Precipitation, Korea: Mean of Osan and Kunsan.....	89
A-80	Maximum Amounts of Daily Precipitation, Mean of German Airbases.....	90
A-81	Maximum Amounts of Daily Precipitation, Worst Case: Korea and Germany.....	91
A-82	Maximum Amounts of Daily Snowfall, Upper Heyford.....	92
A-83	Maximum Amounts of Daily Snowfall, Mean of German Airbases.....	93
A-84	Maximum Amounts of Daily Snowfall, Korea: Mean of Osan and Kunsan.....	94
A-85	Maximum Amounts of Daily Snowfall, Worst Case: Germany.....	95
A-86	Maximum Amounts of Daily Snowfall, Worst Case: Korea.....	96
A-87	Maximum Amounts of Daily Snowdepth, Upper Heyford.....	97
A-88	Maximum Amounts of Daily Snowdepth, Mean of German Airbases.....	98
A-89	Maximum Amounts of Daily Snowdepth, Korea: Mean of Osan and Kunsan.....	99
A-90	Maximum Amounts of Daily Snowdepth, Worst Case: Germany.....	100
A-91	Maximum Amounts of Daily Snowdepth, Worst Case: Korea.....	101
A-92	Daily Amounts of Precipitation, Upper Heyford in January.....	103

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-93	Daily Amounts of Precipitation, Upper Heyford in February.....	104
A-94	Daily Amounts of Precipitation, Upper Heyford in March.....	105
A-95	Daily Amounts of Precipitation, Upper Heyford in April.....	106
A-96	Daily Amounts of Precipitation, Upper Heyford in May.....	107
A-97	Daily Amounts of Precipitation, Upper Heyford in June.....	108
A-98	Daily Amounts of Precipitation, Upper Heyford in July.....	109
A-99	Daily Amounts of Precipitation, Upper Heyford in August.....	110
A-100	Daily Amounts of Precipitation, Upper Heyford in September.....	111
A-101	Daily Amounts of Precipitation, Upper Heyford in October.....	112
A-102	Daily Amounts of Precipitation, Upper Heyford in November.....	113
A-103	Daily Amounts of Precipitation, Upper Heyford in December.....	114
A-104	Daily Amounts of Precipitation,, Mean of German Airbases in January.....	115
A-105	Daily Amounts of Precipitation, Mean of German Airbases in February.....	116
A-106	Daily Amounts of Precipitation, Mean of German Airbases in March.....	117
A-107	Daily Amounts of Precipitation, Mean of German Airbases in April.....	118

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-108	Daily Amounts of Precipitation, Mean of German Airbases in May.....	119
A-109	Daily Amounts of Precipitation, Mean of German Airbases in June.....	120
A-110	Daily Amounts of Precipitation, Mean of German Airbases in July.....	121
A-111	Daily Amounts of Precipitation, Mean of German Airbases in August.....	122
A-112	Daily Amounts of Precipitation, Mean of German Airbases in September.....	123
A-113	Daily Amounts of Precipitation, Mean of German Airbases in October.....	124
A-114	Daily Amounts of Precipitation, Mean of German Airbases in November.....	125
A-115	Daily Amounts of Precipitation, Mean of German Airbases in December.....	126
A-116	Daily Amounts of Precipitation, Osan AFB, Korea in January.....	127
A-117	Daily Amounts of Precipitation, Osan AFB, Korea in February.....	128
A-118	Daily Amounts of Precipitation, Osan AFB, Korea in March.....	129
A-119	Daily Amounts of Precipitation, Osan AFB, Korea in April.....	130
A-120	Daily Amounts of Precipitation, Osan AFB, Korea in May.....	131
A-121	Daily Amounts of Precipitation, Osan AFB, Korea in June.....	132
A-122	Daily Amounts of Precipitation, Osan AFB, Korea in July.....	133

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-123	Daily Amounts of Precipitation, Osan AFB, Korea in August.....	134
A-124	Daily Amounts of Precipitation, Osan AFB, Korea in September.....	135
A-125	Daily Amounts of Precipitation, Osan AFB, Korea in October.....	136
A-126	Daily Amounts of Precipitation, Osan AFB, Korea in November.....	137
A-127	Daily Amounts of Precipitation, Osan AFB, Korea in December.....	138
A-128	Daily Amounts of Snowfall, Upper Heyford in January.....	139
A-129	Daily Amounts of Snowfall, Upper Heyford in February.....	140
A-130	Daily Amounts of Snowfall, Upper Heyford in March.....	141
A-131	Daily Amounts of Snowfall, Upper Heyford in April.....	142
A-132	Daily Amounts of Snowfall, Upper Heyford in November.....	143
A-133	Daily Amounts of Snowfall, Upper Heyford in December.....	144
A-134	Daily Amounts of Snowfall, Mean of German Airbases in January.....	145
A-135	Daily Amounts of Snowfall, Mean of German Airbases in February.....	146
A-136	Daily Amounts of Snowfall, Mean of German Airbases in March.....	147
A-137	Daily Amounts of Snowfall, Mean of German Airbases in April.....	148

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-138	Daily Amounts of Snowfall, Mean of German Airbases in November.....	149
A-139	Daily Amounts of Snowfall, Mean of German Airbases in December.....	150
A-140	Daily Amounts of Snowfall, Mean of Korean Airbases in January.....	151
A-141	Daily Amounts of Snowfall, Mean of Korean Airbases in February.....	152
A-142	Daily Amounts of Snowfall, Mean of Korean Airbases in March.....	153
A-143	Daily Amounts of Snowfall, Mean of Korean Airbases in November.....	154
A-144	Daily Amounts of Snowfall, Mean of Korean Airbases in December.....	155
A-145	Daily Amounts of Snowdepth, Upper Heyford in January.....	156
A-146	Daily Amounts of Snowdepth, Upper Heyford in February.....	157
A-147	Daily Amounts of Snowdepth, Upper Heyford in March.....	158
A-148	Daily Amounts of Snowdepth, Upper Heyford in November.....	159
A-149	Daily Amounts of Snowdepth, Upper Heyford in December.....	160
A-150	Daily Amounts of Snowdepth, Mean of German Airbases in January.....	161
A-151	Daily Amounts of Snowdepth, Mean of German Airbases in February.....	162
A-152	Daily Amounts of Snowdepth, Mean of German Airbases in March.....	163

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-153	Daily Amounts of Snowdepth, Mean of German Airbases in November.....	164
A-154	Daily Amounts of Snowdepth, Mean of German Airbases in December.....	165
A-155	Daily Amounts of Snowdepth, Mean of Korean Airbases in January.....	166
A-156	Daily Amounts of Snowdepth, Mean of Korean Airbases in February.....	167
A-157	Daily Amounts of Snowdepth, Mean of Korean Airbases in March.....	168
A-158	Daily Amounts of Snowdepth, Mean of Korean Airbases in November.....	169
A-159	Daily Amounts of Snowdepth, Mean of Korean Airbases in December.....	170
A-160	Frequency of Occurrence of Weather Conditions, Upper Heyford.....	172
A-161	Frequency of Occurrence of Weather Conditions, Mean of German Airbases.....	173
A-162	Frequency of Occurrence of Weather Conditions, Mean of Korean Airbases.....	174
A-163	Frequency of Occurrence of Weather Conditions, Worst Case: Germany.....	175
A-164	Frequency of Occurrence of Weather Conditions, Worst Case: Korea.....	176
A-165	Duration of Precipitation, Upper Heyford - January.....	180
A-166	Duration of Precipitation, Upper Heyford - February.....	181
A-167	Duration of Precipitation, Upper Heyford - March.....	182

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-168	Duration of Precipitation, Upper Heyford - April.....	183
A-169	Duration of Precipitation, Upper Heyford - May.....	184
A-170	Duration of Precipitation, Upper Heyford - June.....	185
A-171	Duration of Precipitation, Upper Heyford - July.....	186
A-172	Duration of Precipitation, Upper Heyford - August.....	187
A-173	Duration of Precipitation, Upper Heyford - September.....	188
A-174	Duration of Precipitation, Upper Heyford - October.....	189
A-175	Duration of Precipitation, Upper Heyford - November.....	190
A-176	Duration of Precipitation, Upper Heyford - December.....	191
A-177	Duration of Precipitation, Mean of German Airbases - January.....	192
A-178	Duration of Precipitation, Mean of German Airbases - February.....	193
A-179	Duration of Precipitation, Mean of German Airbases - March.....	194
A-180	Duration of Precipitation, Mean of German Airbases - April.....	195
A-181	Duration of Precipitation, Mean of German Airbases - May.....	196
A-182	Duration of Precipitation, Mean of German Airbases - June.....	197

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-183	Duration of Precipitation, Mean of German Airbases - July.....	198
A-184	Duration of Precipitation, Mean of German Airbases - August.....	199
A-185	Duration of Precipitation, Mean of German Airbases - September.....	200
A-186	Duration of Precipitation, Mean of German Airbases - October.....	201
A-187	Duration of Precipitation, Mean of German Airbases - November.....	202
A-188	Duration of Precipitation, Mean of German Airbases - December.....	203
A-189	Duration of Precipitation, Mean of Korean Airbases - January.....	204
A-190	Duration of Precipitation, Mean of Korean Airbases - February.....	205
A-191	Duration of Precipitation, Mean of Korean Airbases - March.....	206
A-192	Duration of Precipitation, Mean of Korean Airbases - April.....	207
A-193	Duration of Precipitation, Mean of Korean Airbases - May.....	208
A-194	Duration of Precipitation, Mean of Korean Airbases - June.....	209
A-195	Duration of Precipitation, Mean of Korean Airbases - July.....	210
A-196	Duration of Precipitation, Mean of Korean Airbases - August.....	211
A-197	Duration of Precipitation, Mean of Korean Airbases - September.....	212

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-198	Duration of Precipitation, Mean of Korean Airbases - October.....	213
A-199	Duration of Precipitation, Mean of Korean Airbases - November.....	214
A-200	Duration of Precipitation, Mean of Korean Airbases - December.....	215
A-201	Frequency of Occurrence of Indicated Visibilities, Upper Heyford.....	218
A-202	Frequency of Occurrence of Indicated Visibilities, Worst Case: Germany.....	219
A-203	Frequency of Occurrence of Indicated Visibilities, Worst Case: Korea.....	220
A-204	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - January.....	222
A-205	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - February.....	223
A-206	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - April.....	224
A-207	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - September.....	225
A-208	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - October.....	226
A-209	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - November.....	227
A-210	Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - December.....	228
A-211	Frequency of Occurrence of Visibility $<$ 400 Feet, Worst Case: Worldwide	230
A-212	Frequency of Occurrence of Visibility $<$ 300 Feet, Worst Case: Worldwide	231

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-213	Frequency of Occurrence of Visibility < 200 Feet, Worst Case: Worldwide	232
A-214	Frequency of Occurrence of Visibility < 100 Feet Worst Case: Worldwide	233
A-215	Daily Peak Gusts, Upper Heyford.....	236
A-216	Daily Peak Gusts, Mean of German Airbases.....	237
A-217	Daily Peak Gusts, Korea: Mean of Osan and Kunsan.....	238
A-218	Daily Peak Gusts, Worst Case: Germany.....	239
A-219	Daily Peak Gusts, Worst Case: Korea.....	240
A-220	Annual Frequency of Occurrence of Wind Speeds, Upper Heyford.....	244
A-221	Frequency of Occurrence of Wind Speeds, Upper Heyford in January.....	245
A-222	Frequency of Occurrence of Wind Speeds, Upper Heyford in February.....	246
A-223	Frequency of Occurrence of Wind Speeds, Upper Heyford in March.....	247
A-224	Frequency of Occurrence of Wind Speeds, Upper Heyford in April.....	248
A-225	Frequency of Occurrence of Wind Speeds, Upper Heyford in May.....	249
A-226	Frequency of Occurrence of Wind Speeds, Upper Heyford in June.....	250
A-227	Frequency of Occurrence of Wind Speeds, Upper Heyford in July.....	251

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-228	Frequency of Occurrence of Wind Speeds, Upper Heyford in August.....	252
A-229	Frequency of Occurrence of Wind Speeds, Upper Heyford in September.....	253
A-230	Frequency of Occurrence of Wind Speeds, Upper Heyford in October.....	254
A-231	Frequency of Occurrence of Wind Speeds, Upper Heyford in November.....	255
A-232	Frequency of Occurrence of Wind Speeds, Upper Heyford in December.....	256
A-233	Annual Frequency of Occurrence of Wind Speeds, Germany.....	257
A-234	Frequency of Occurrence of Wind Speeds, Germany in January.....	258
A-235	Frequency of Occurrence of Wind Speeds, Germany in February.....	259
A-236	Frequency of Occurrence of Wind Speeds, Germany in March.....	260
A-237	Frequency of Occurrence of Wind Speeds, Germany in April.....	261
A-238	Frequency of Occurrence of Wind Speeds, Germany in May.....	262
A-239	Frequency of Occurrence of Wind Speeds, Germany in June.....	263
A-240	Frequency of Occurrence of Wind Speeds, Germany in July.....	264
A-241	Frequency of Occurrence of Wind Speeds, Germany in August.....	265
A-242	Frequency of Occurrence of Wind Speeds, Germany in September.....	266

LIST OF FIGURES (CONTINUED)

Figure	Title	Page
A-243	Frequency of Occurrence of Wind Speeds, Germany in October	267
A-244	Frequency of Occurrence of Wind Speeds, Germany in November.....	268
A-245	Frequency of Occurrence of Wind Speeds, Germany in December.....	269
A-246	Annual Frequency of Occurrence of Wind Speeds, Korea.....	270
A-247	Frequency of Occurrence of Wind Speeds, Korea in January.....	271
A-248	Frequency of Occurrence of Wind Speeds, Korea in February.....	272
A-249	Frequency of Occurrence of Wind Speeds, Korea in March.....	273
A-250	Frequency of Occurrence of Wind Speeds, Korea in April.....	274
A-251	Frequency of Occurrence of Wind Speeds, Korea in May.....	275
A-252	Frequency of Occurrence of Wind Speeds, Korea in June.....	276
A-253	Frequency of Occurrence of Wind Speeds, Korea in July.....	277
A-254	Frequency of Occurrence of Wind Speeds, Korea in August.....	278
A-255	Frequency of Occurrence of Wind Speeds, Korea in September.....	279
A-256	Frequency of Occurrence of Wind Speeds, Korea in October.....	280
A-257	Frequency of Occurrence of Wind Speeds, Korea in November.....	281

LIST OF FIGURES (CONCLUDED)

Figure	Title	Page
A-258	Frequency of Occurrence of Wind Speeds, Korea in December.....	282
A-259	Mean Relative Humidity, Upper Heyford.....	285
A-260	Mean Relative Humidity, Mean of German Airbases.....	286
A-261	Mean Relative Humidity, Mean of Korean Airbases.....	287
A-262	Ranges of Relative Humidity, Upper Heyford - Annual.....	289
A-263	Ranges of Relative Humidity, Mean of German Airbases - Annual.....	290
A-264	Ranges of Relative Humidity, Mean of Korean Airbases - Annual.....	291

LIST OF TABLES

Table	Title	Page
A-1	Estimates for 2-Year 1-Hour Rainfall.....	86
A-2	Maximum Amounts of Precipitation - Worst Case.....	178
A-3	Ninety-Ninth Percentile Wind Chill Temperatures.....	242

APPENDIX A

WEATHER DATA

The following is a graphical presentation of the weather conditions which occur in the English, German and Korean theaters. USAFETAC collected and compiled the data used for this characterization; most were contained in RUSSWOs (Revised Uniform Summaries of Surface Weather Observations). The data were based on variable periods of record, ranging from a few to many years. Each of the summaries is derived from observations taken at hourly intervals.

For some weather conditions, the percentage frequency of occurrence is less than 1 percent for all observations. This occurs in four major data categories:

- (1) Observations of snow or freezing rain in summer months,
- (2) Observations of temperatures $\leq 32^{\circ}\text{F}$ in summer months,
- (3) Observations of temperatures $\geq 80^{\circ}\text{F}$ in winter months, and
- (4) Observations of low visibility in summer months.

In these cases, the graphs are omitted.

Maximum (minimum) values across a theater were computed by averaging the maximum (minimum) values recorded for each airbase within the theater. The worst case was assumed to be the largest (smallest) observation recorded for the entire theater. Thus, since the English theater consists only of Upper Heyford, the maximum (minimum) value is also the worst case. Data summaries labeled "Worst Case - Worldwide" indicate the maximum (minimum) values recorded in the 10 airbases considered in this study.

In calculating mean values over several airbases, some round-off error is naturally produced. Values strictly less than 1 percent were rounded off to be 0 percent; otherwise, the number was rounded up for decimal portions greater than or equal to .5. As a result, percent of occurrence of exclusive events does not always sum to 100 percent.

The data summaries are grouped into these five categories of conditions:

- (1) Temperature,
- (2) Precipitation,
- (3) Visibility.

(4) Wind and Wind Chill, and

(5) Relative Humidity.

An example is given with each set of graphs to illustrate the statistics represented. In these discussions, the phrases "of the time" and "of the observations" are assumed to be synonymous.

1. TEMPERATURE

a. Monthly Temperature Ranges

For each airbase in a theater, the maximum and minimum temperatures were recorded every day within a given month. Three types of statistics were subsequently calculated from this data. The mean maximum (minimum) temperature was computed by averaging all the maximum (minimum) temperatures recorded within the theater.

The largest (smallest) of the maximum (minimum) temperature observations for each airbase was determined. These values were averaged across each theater to calculate the absolute maximum (absolute minimum) temperature. The greatest and smallest of these values were labeled as worst-case temperatures of the theater.

The annual mean maximum (annual mean minimum) was computed by averaging the mean maximum (minimum) over the 12 months.

EXAMPLE: At Upper Heyford in January, the mean daily minimum temperature is 22°F (Figure A-1). However, an absolute minimum temperature of 8°F has also been recorded in January. That is, among the daily minimum temperatures averaged together to obtain a mean of 22°F, the lowest recorded was 8°F.

EXAMPLE: On the graph labeled "Worst Case: Korea" (Figure A-5), the lowest temperature in March, 11°F, is the minimum of all values recorded in March at Osan and Kunsan. This is in distinction to the absolute minimum shown in Figure A-3, where the minimum temperatures recorded at Osan and Kunsan are averaged, yielding a value of 15° for March.

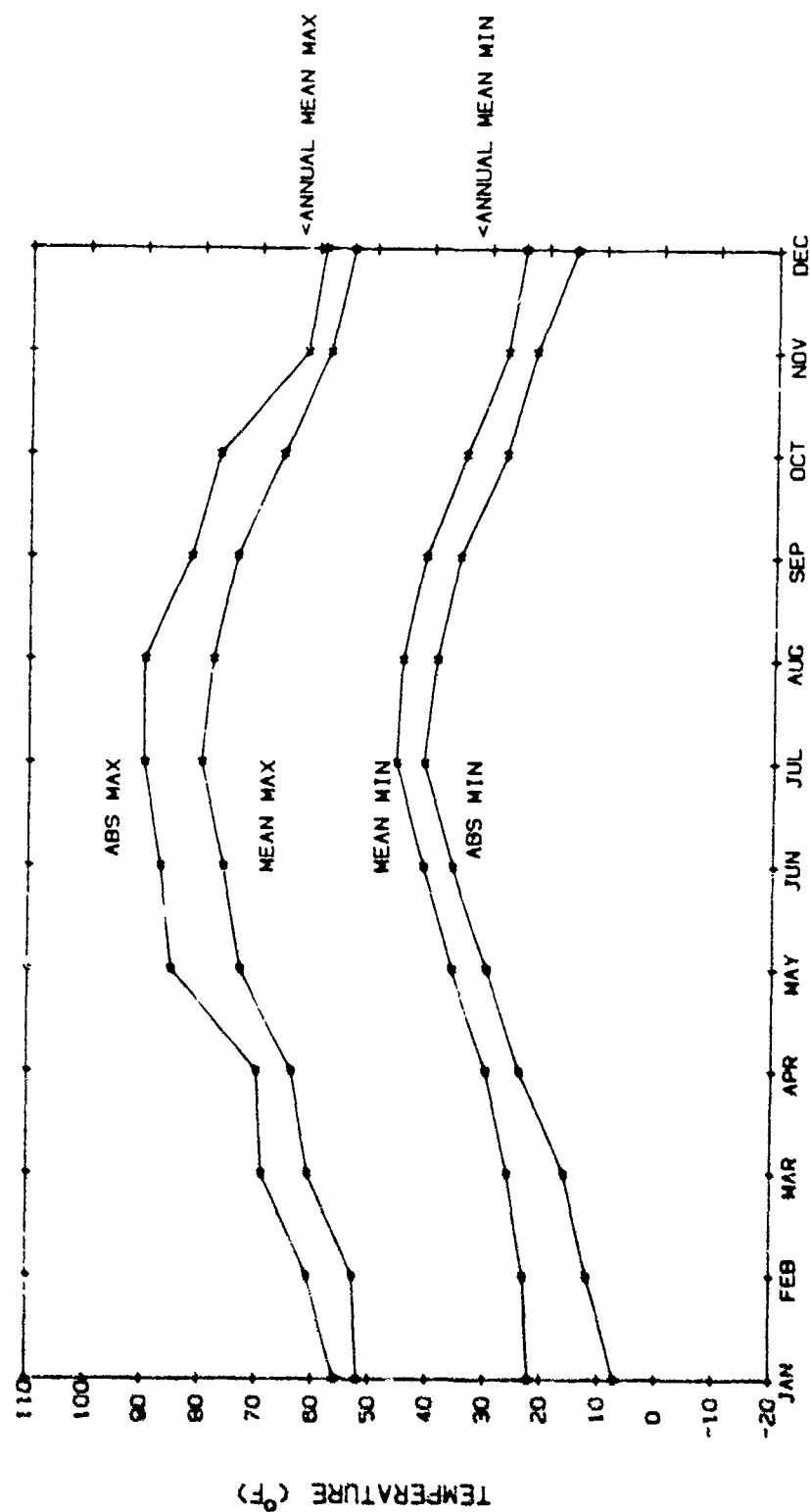


Figure A-1. Monthly Temperature Ranges, Upper Heyford.

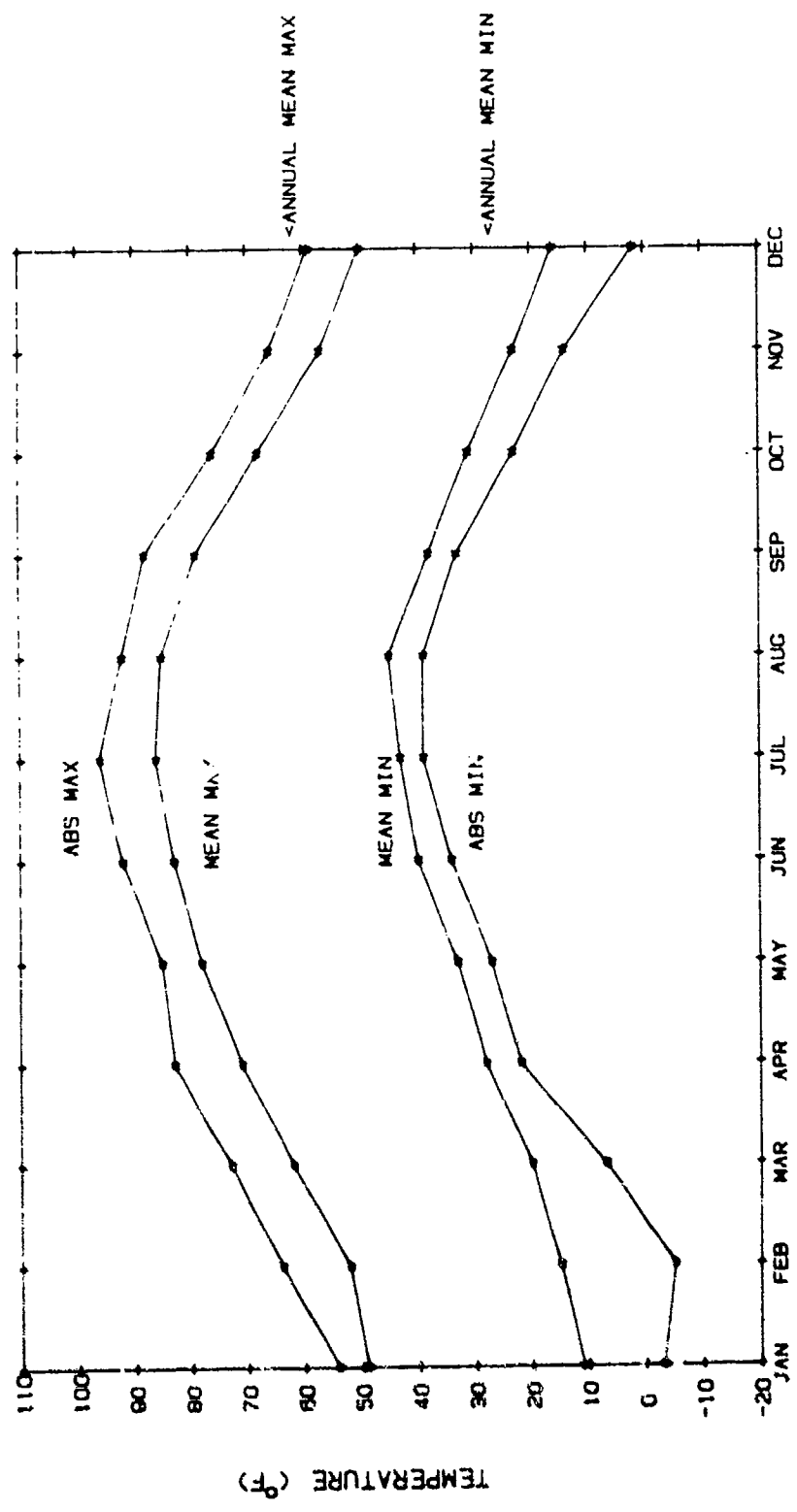


Figure A-2. Monthly Temperature Ranges, Mean of German Airbases.

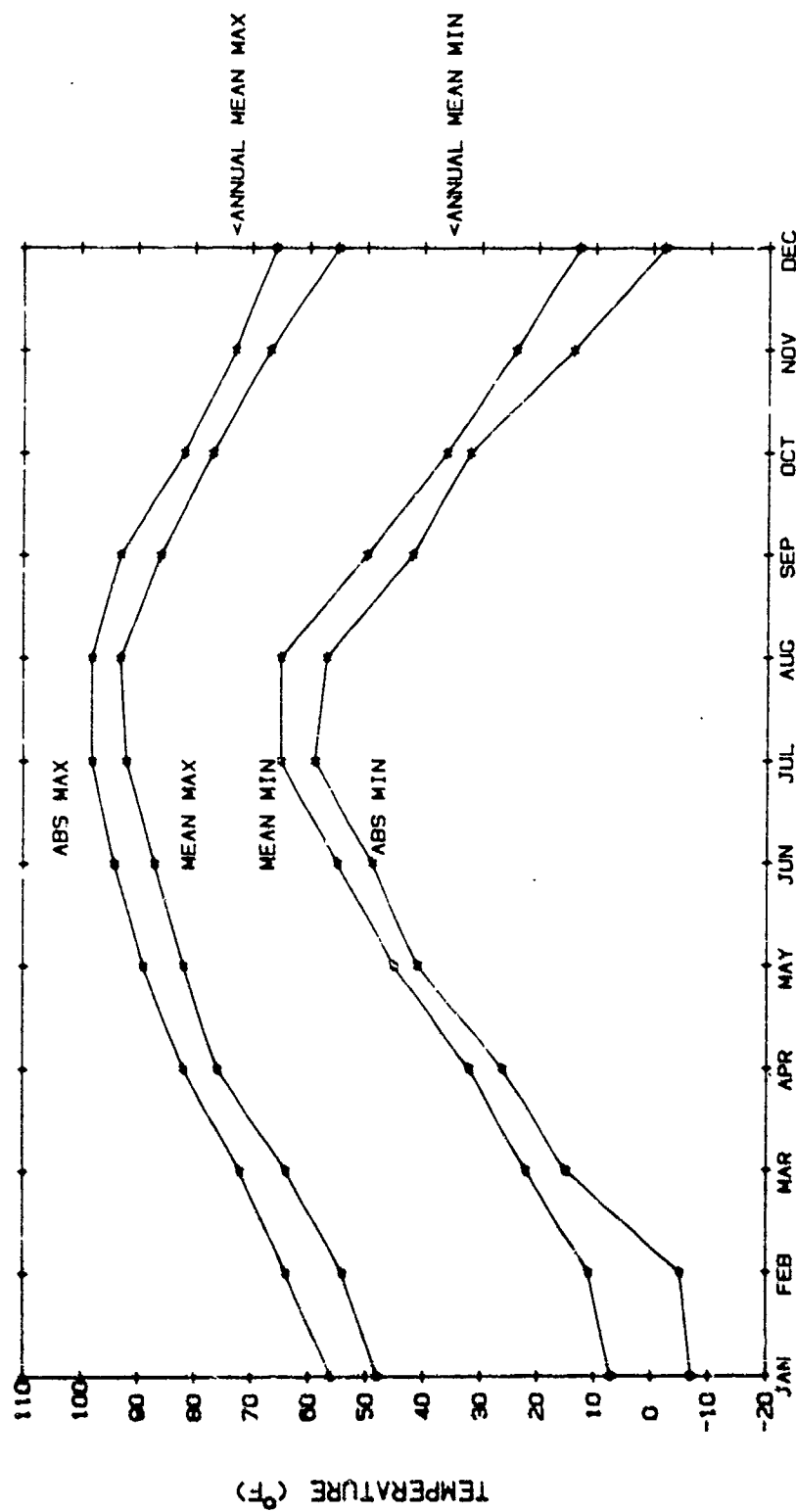


Figure A-3. Monthly Temperature Ranges, Korea: Mean of Osan and Kunsan.

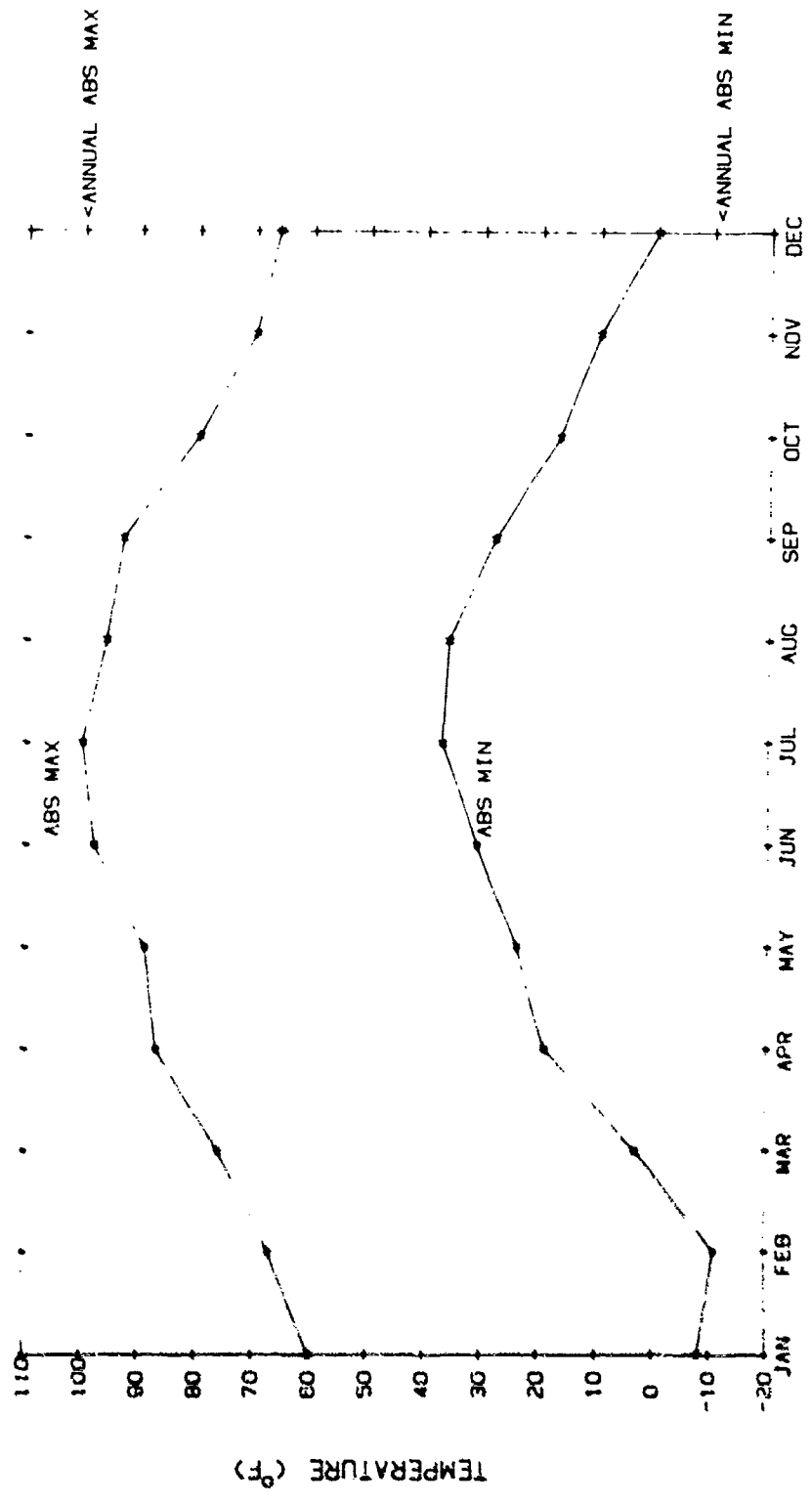


Figure A-4. Monthly Temperature Ranges, Worst Case: Germany.

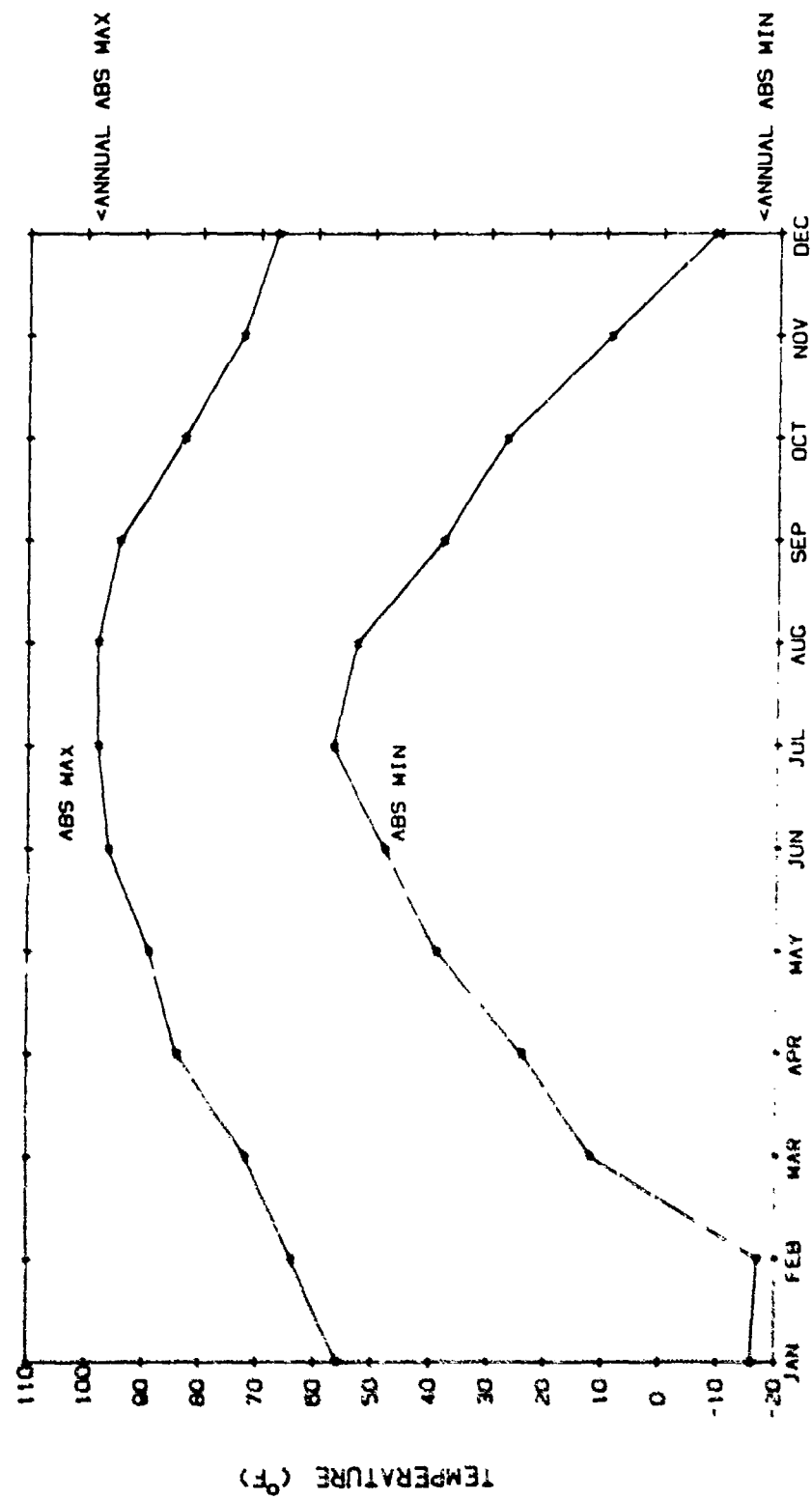


Figure A-5. Monthly Temperature Ranges, Worst Case: Korea.

b. Daily Minimum/Mean/Maximum Temperature Range

For each airbase in a theater, the temperature was recorded hourly. These data were combined into 24-hour groups and daily maximum, daily mean, and daily minimum temperatures were determined. Tables were subsequently calculated to represent frequency of occurrence of these temperatures. These probabilities of occurrence were averaged across each theater to derive the frequency of occurrence for the theater. The following set of graphs indicates that, for each month, 98 percent of all daily minimum (mean/maximum) temperatures fall within the range, 1 percent lie above the range, and 1 percent lie below the range.

For the worst case graphs, the minimum (maximum) value for the theater represents the lowest (highest) 1-percent level of all bases in that theater. Since these contain data from several airbases, it is no longer true that exactly 98 percent of the values fall within the range. In fact, these curves contain more than 98 percent of the values.

EXAMPLE: In January at Upper Heyford (Figure A-7), 98 percent of the daily mean temperatures are between 22°F and 53°F, 1 percent are less than 22°F, and 1 percent are greater than 53°F.

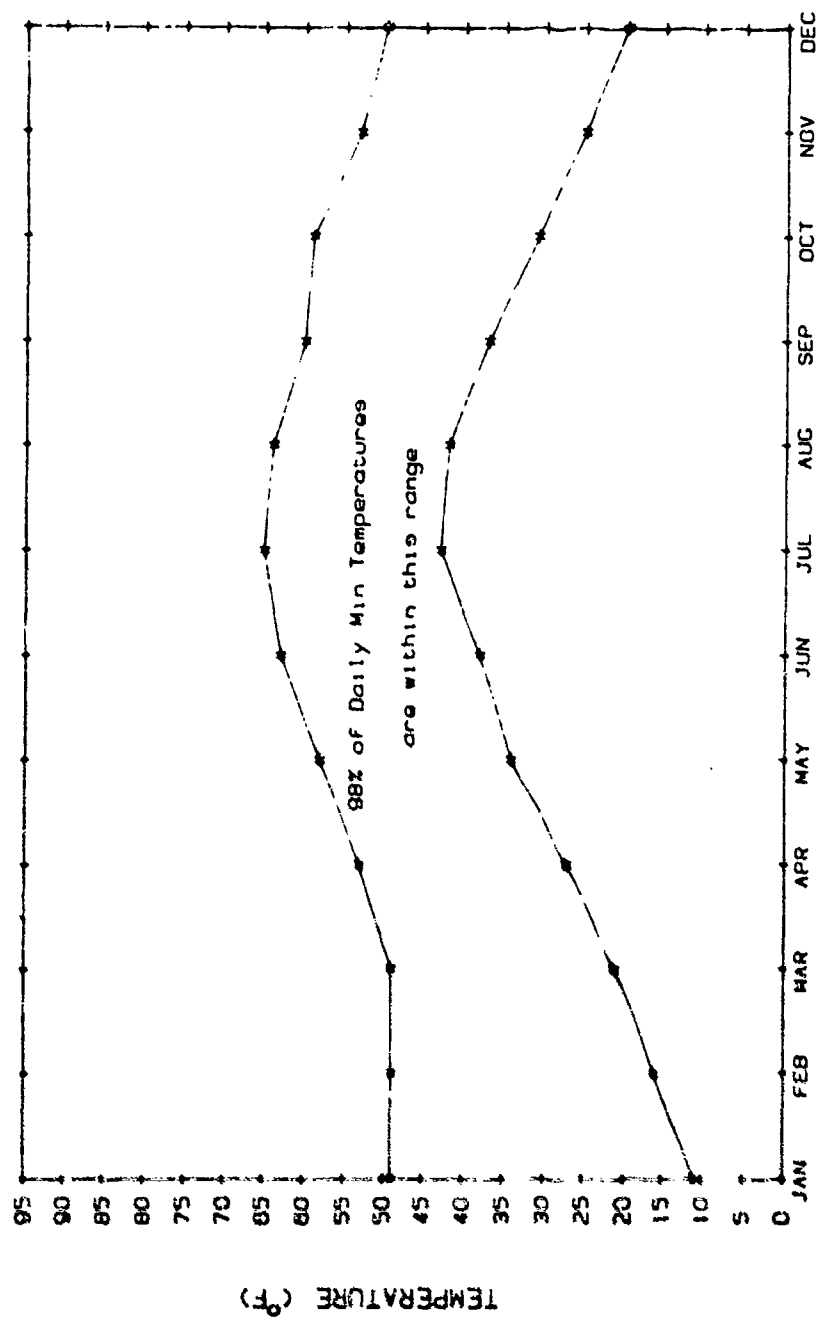


Figure A-6. Daily Minimum Temperature Range, Upper Heyford.

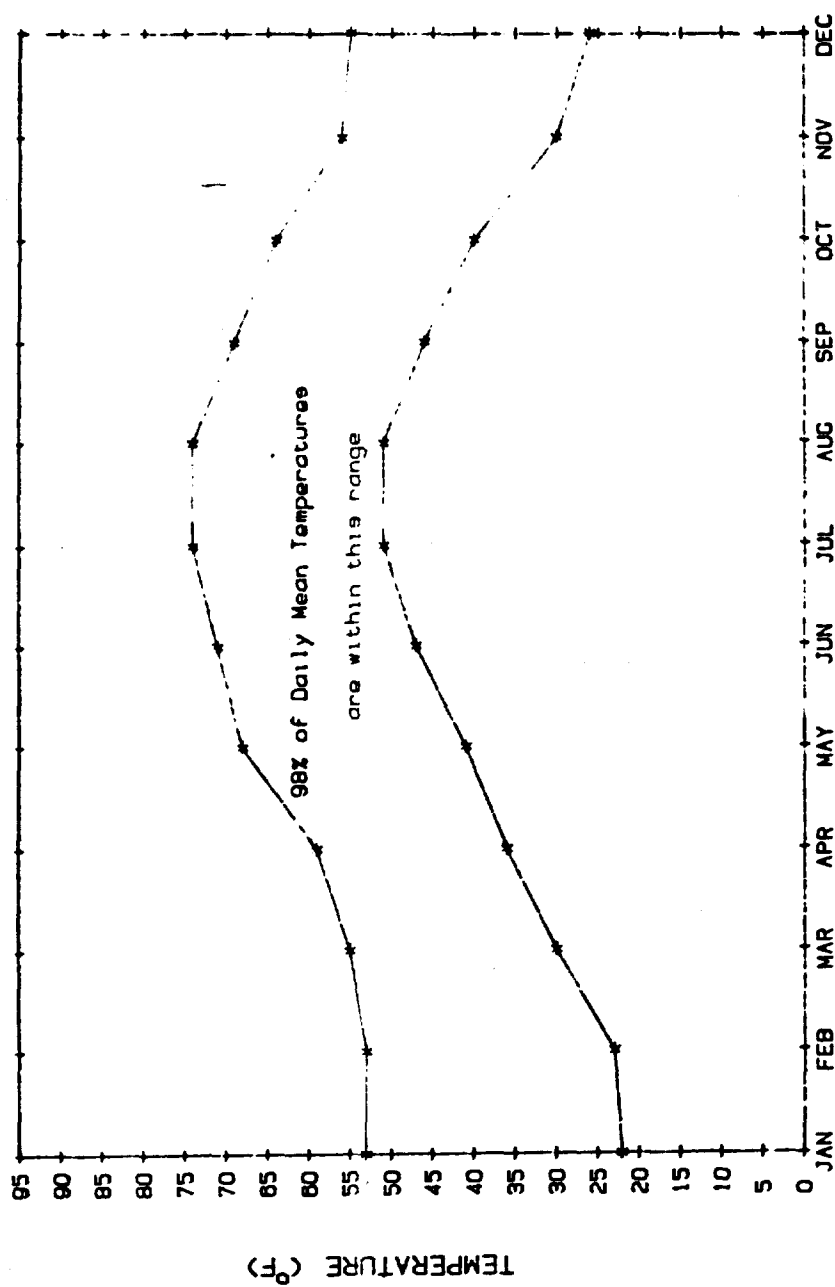


Figure A-7. Daily Mean Temperature Range, Upper Heyford.

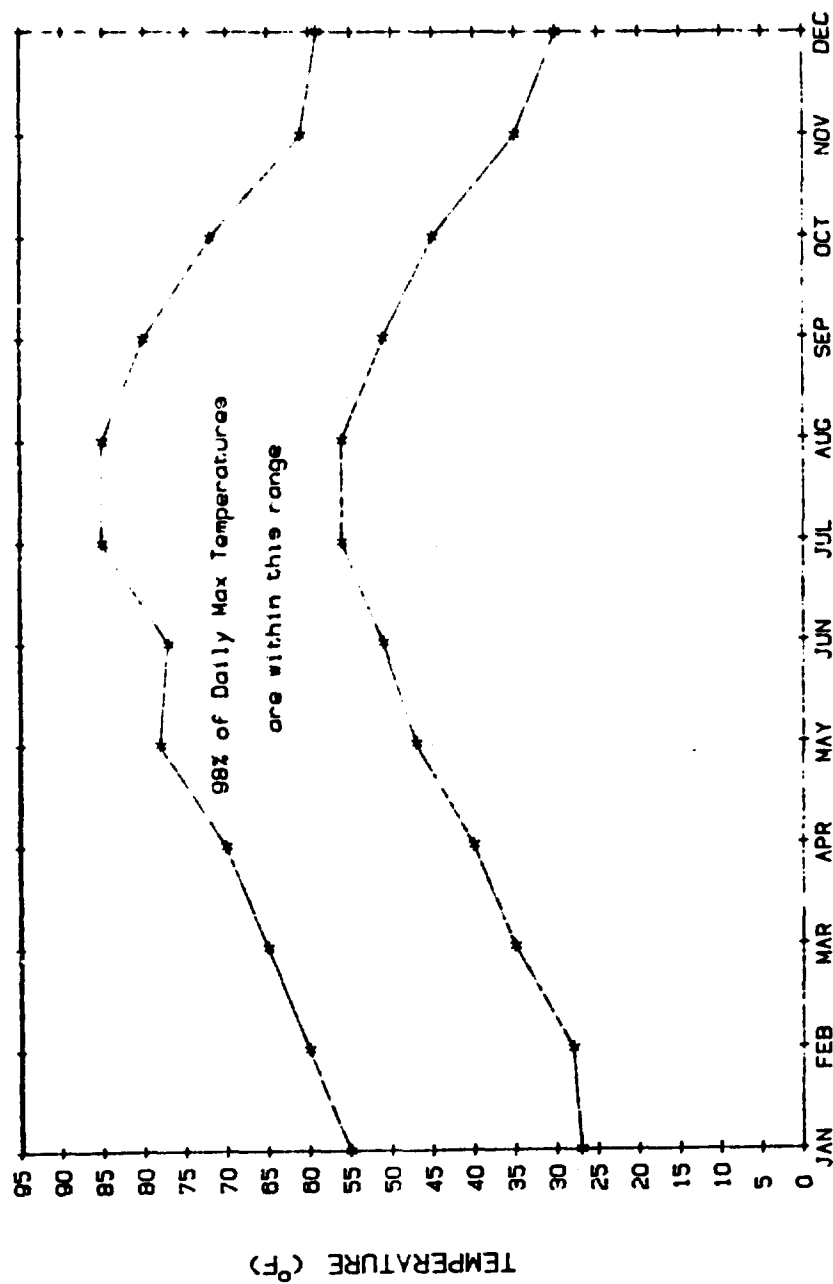


Figure A-8. Daily Maximum Temperature Range, Upper Heyford.

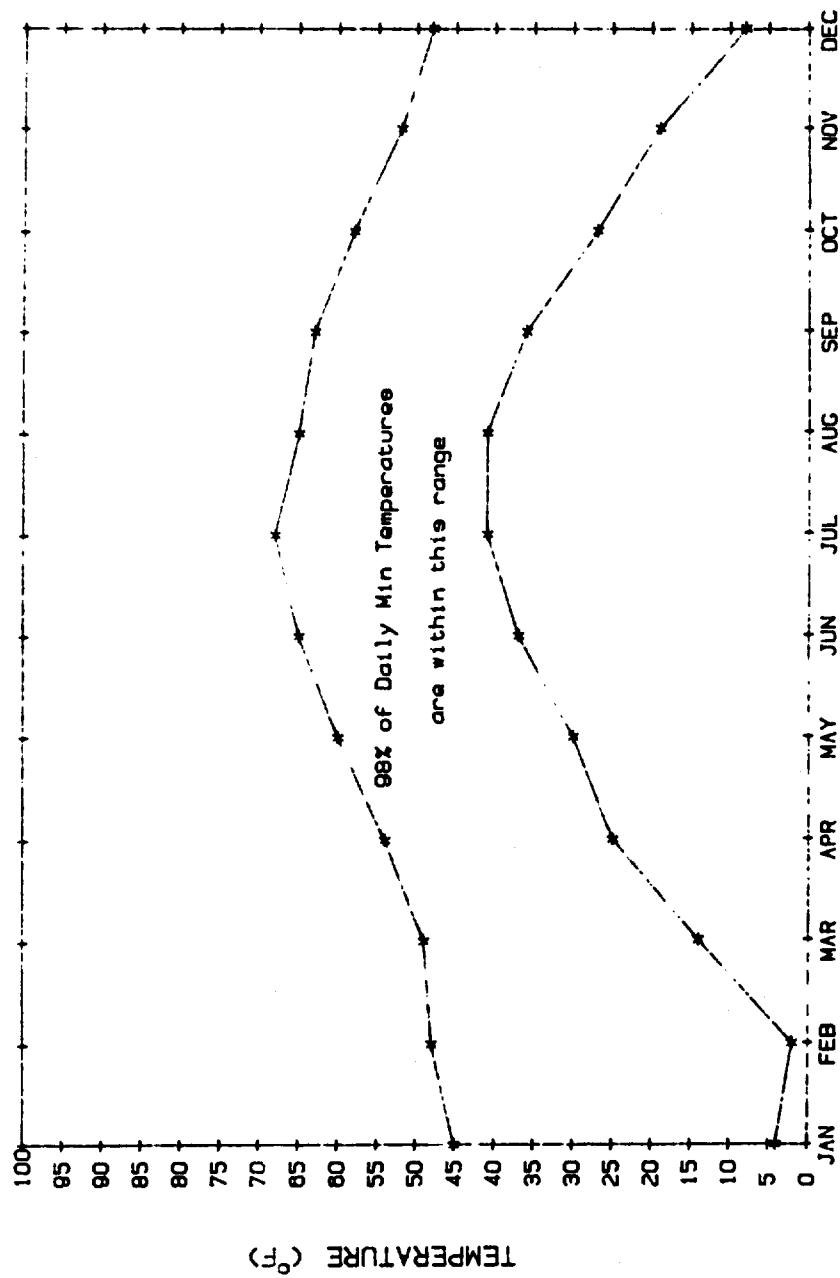


Figure A-9. Daily Minimum Temperature Range, Mean of German Airbases.

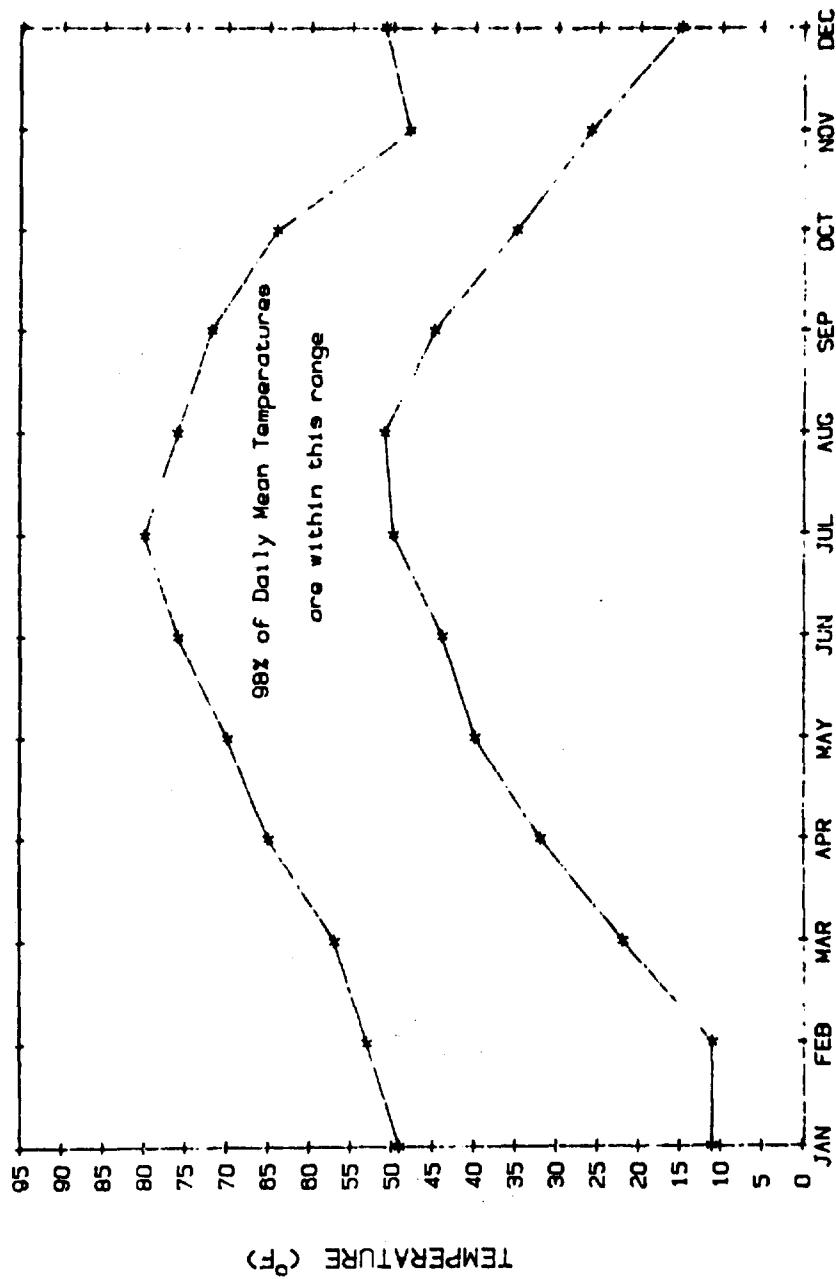


Figure A-10. Daily Mean Temperature Range, Mean of German Airbases.

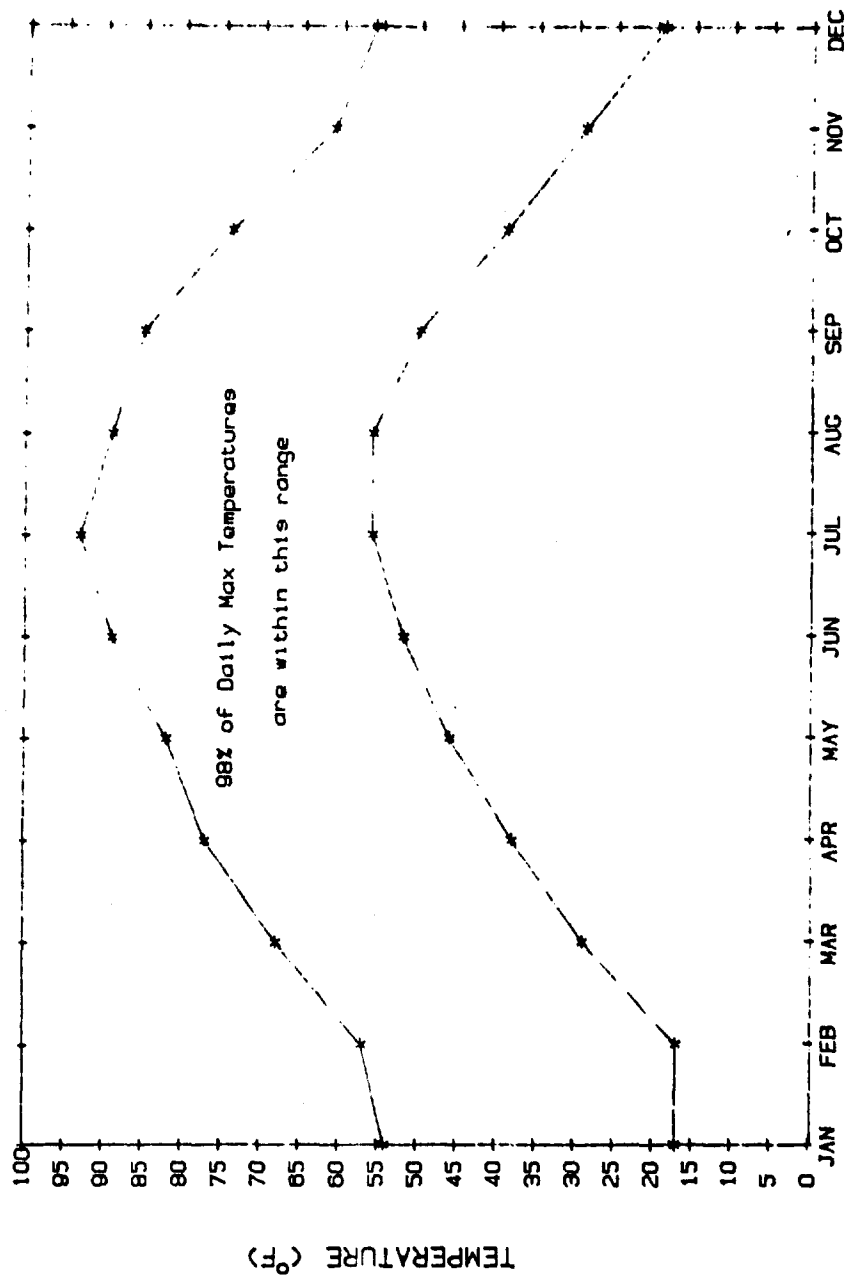


Figure A-11. Daily Maximum Temperature Range, Mean of German Airbases.

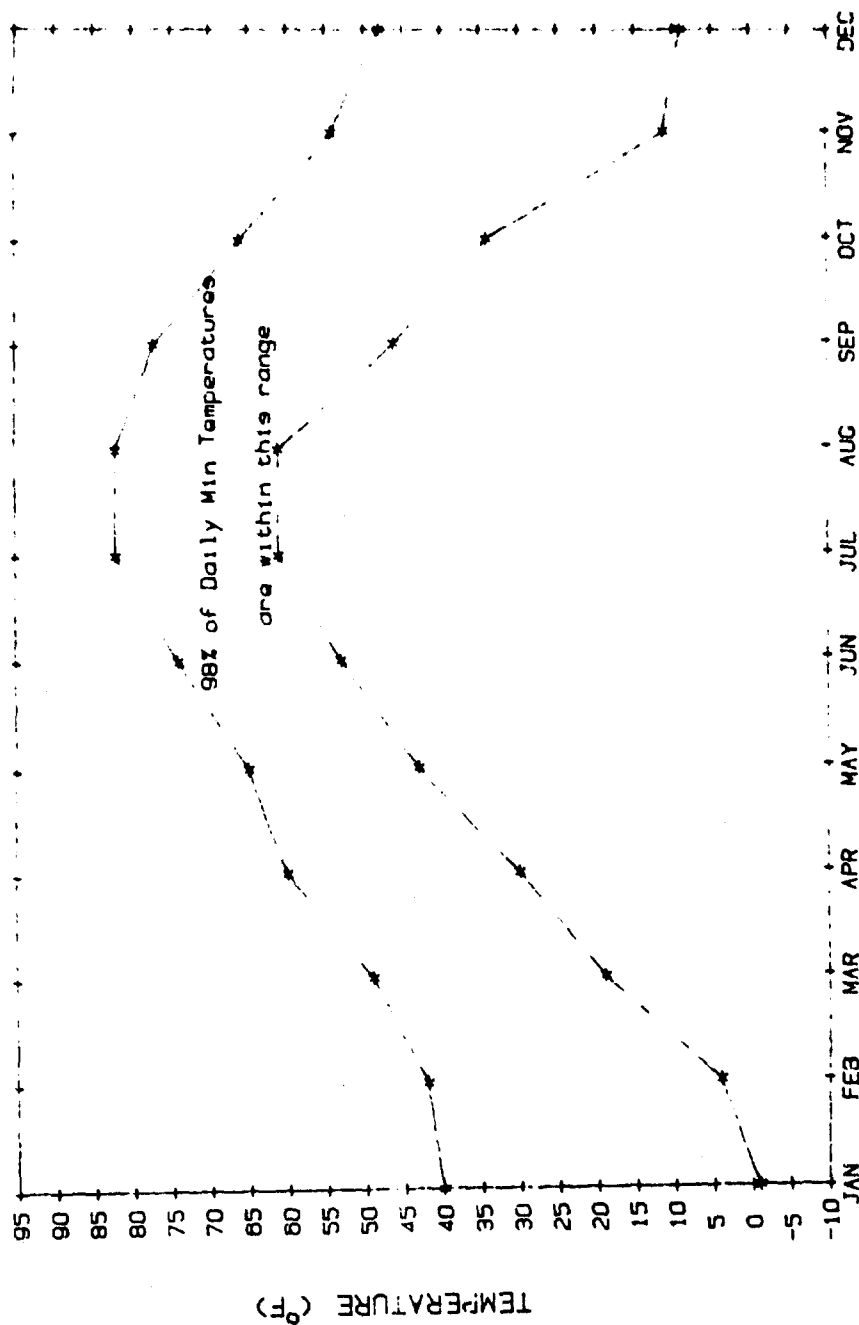


Figure A-12. Daily Minimum Temperature Range, Korea: Mean of Osan and Kunsan.

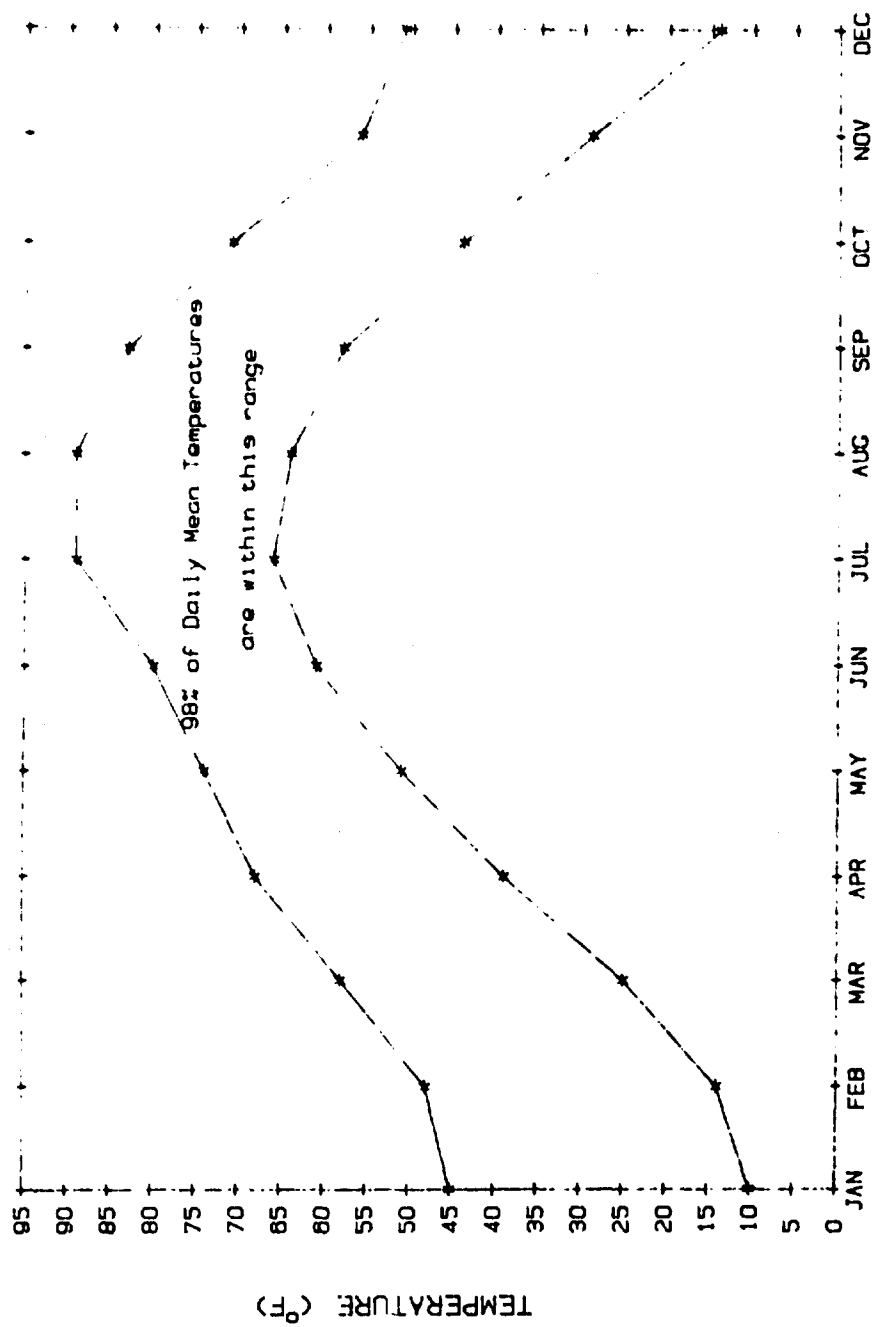


Figure A-13. Daily Mean Temperature Range, Korea: Mean of Osan and Kunsan.

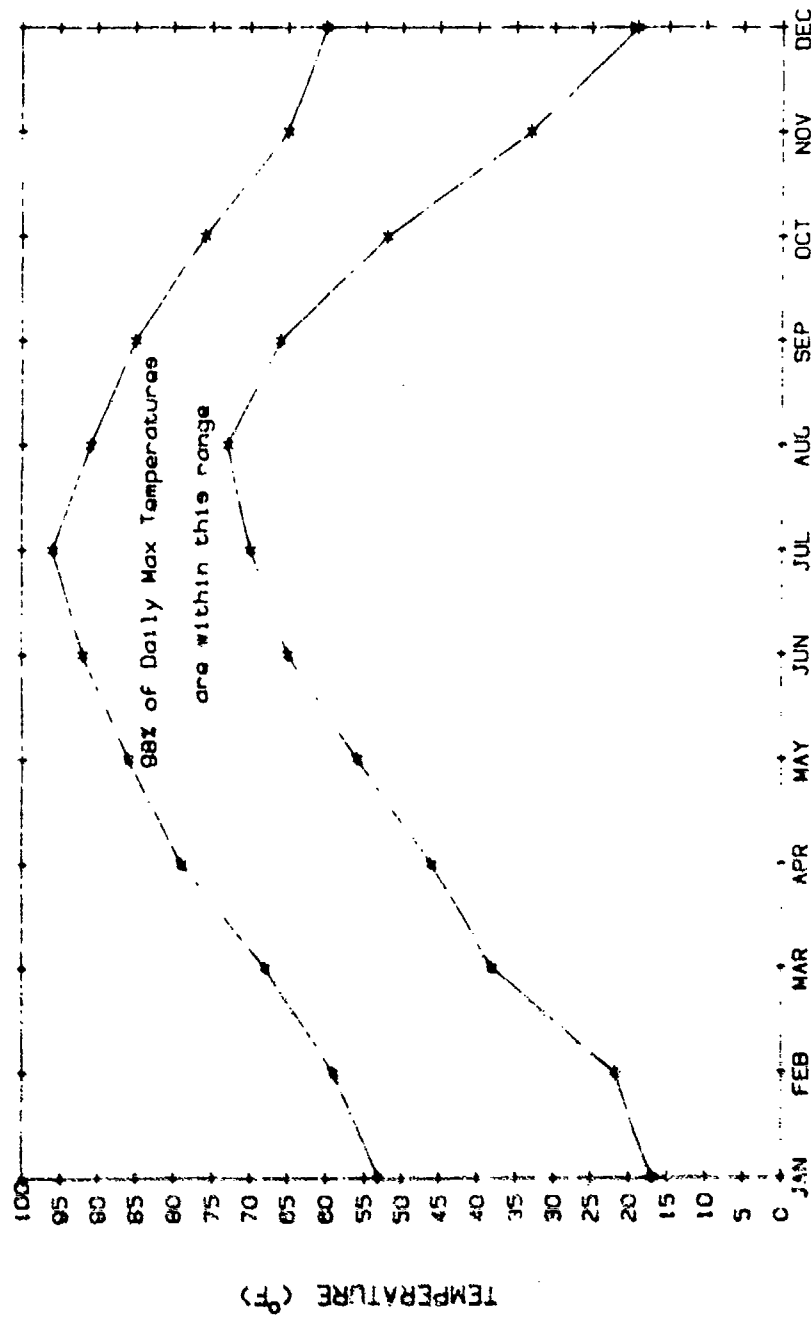


Figure A-14. Daily Maximum Temperature Range, Korea: Mean of Osan and Kunsan.

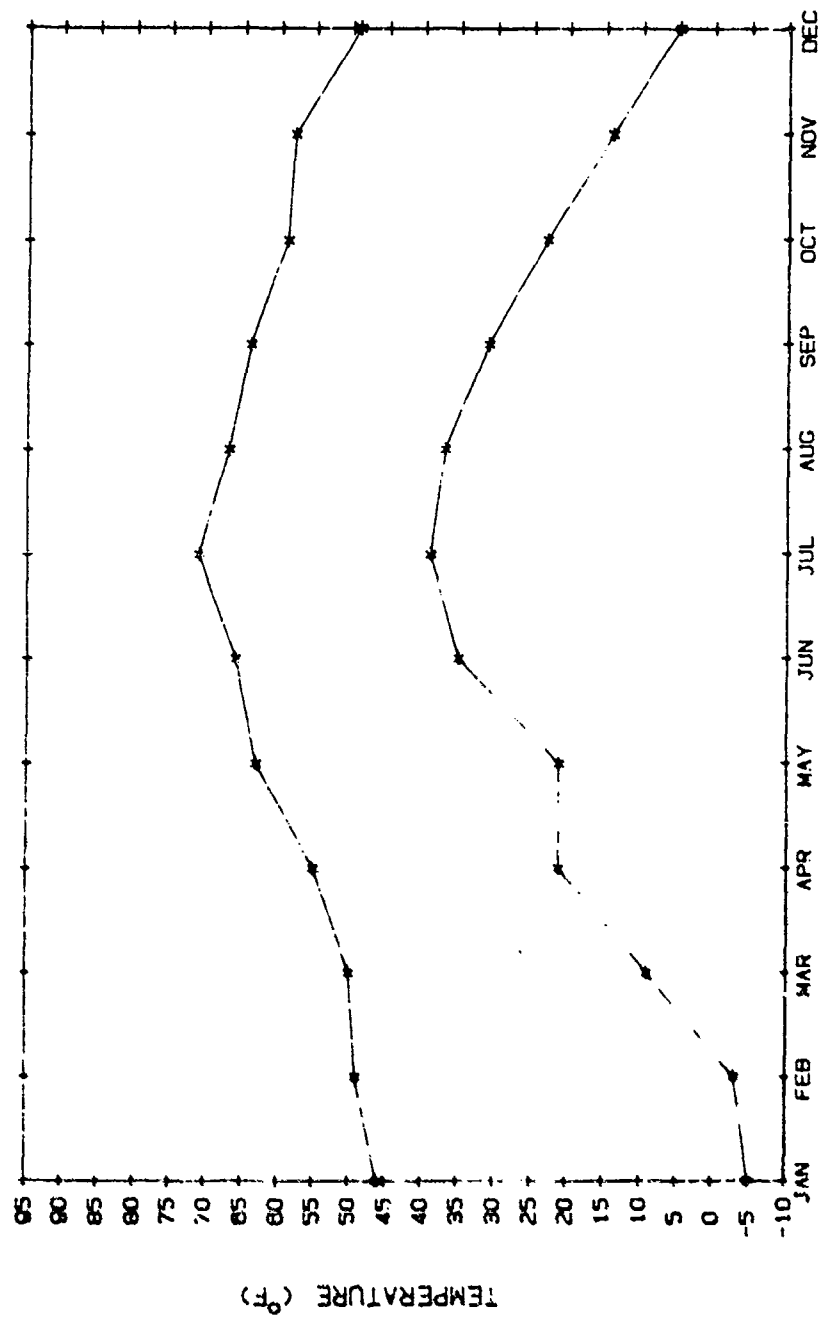


Figure A-15. Daily Minimum Temperature Range, Worst Case: Germany.

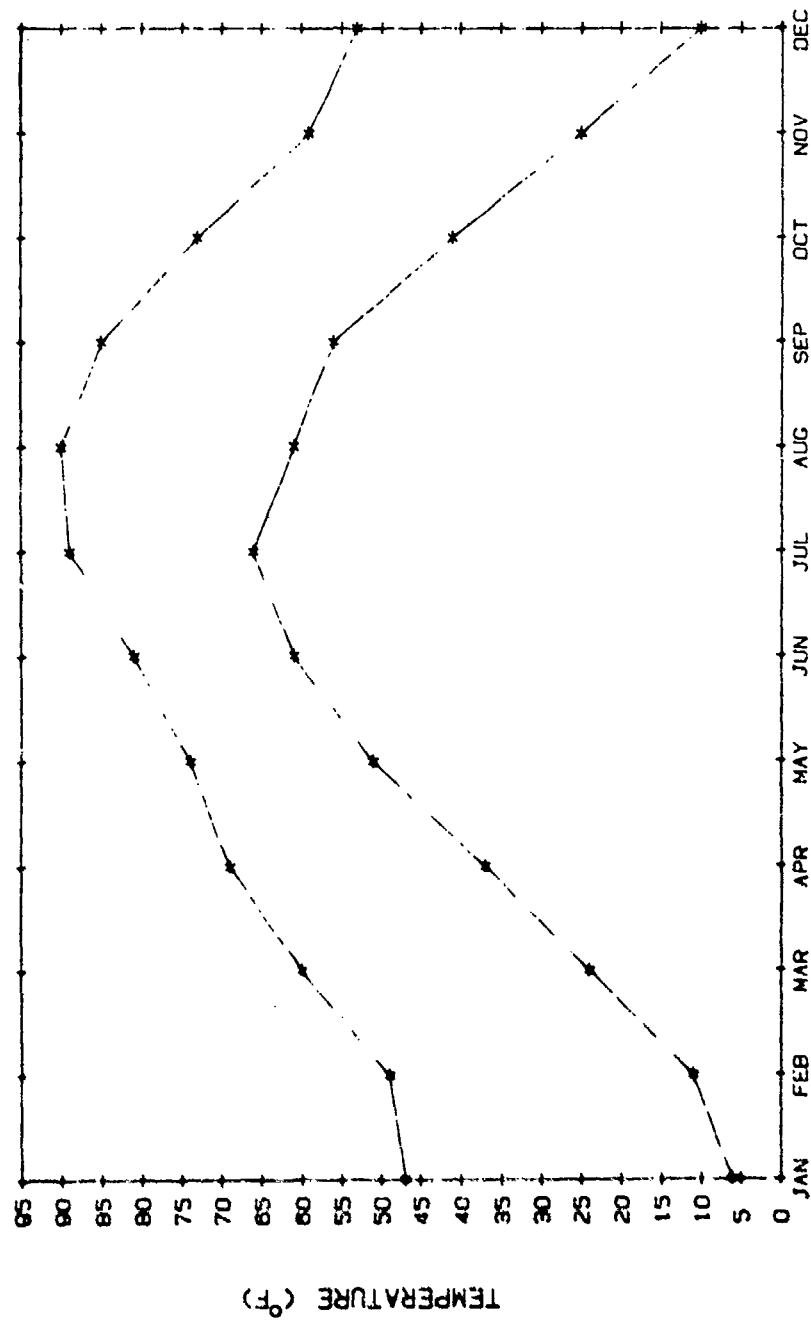


Figure A-16. Daily Mean Temperature Range, Worst Case: Germany.

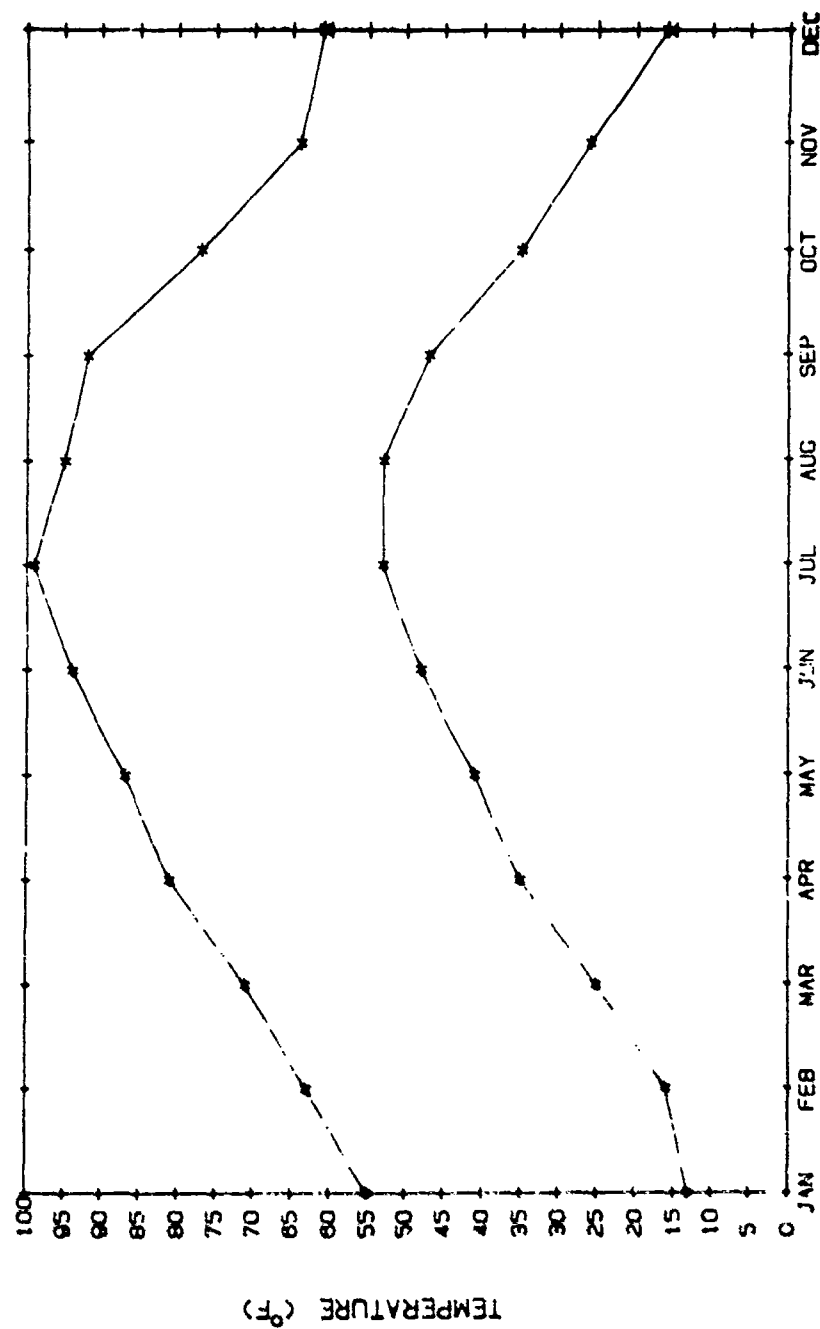


Figure A-17. Daily Maximum Temperature Range, Worst Case: Germany.

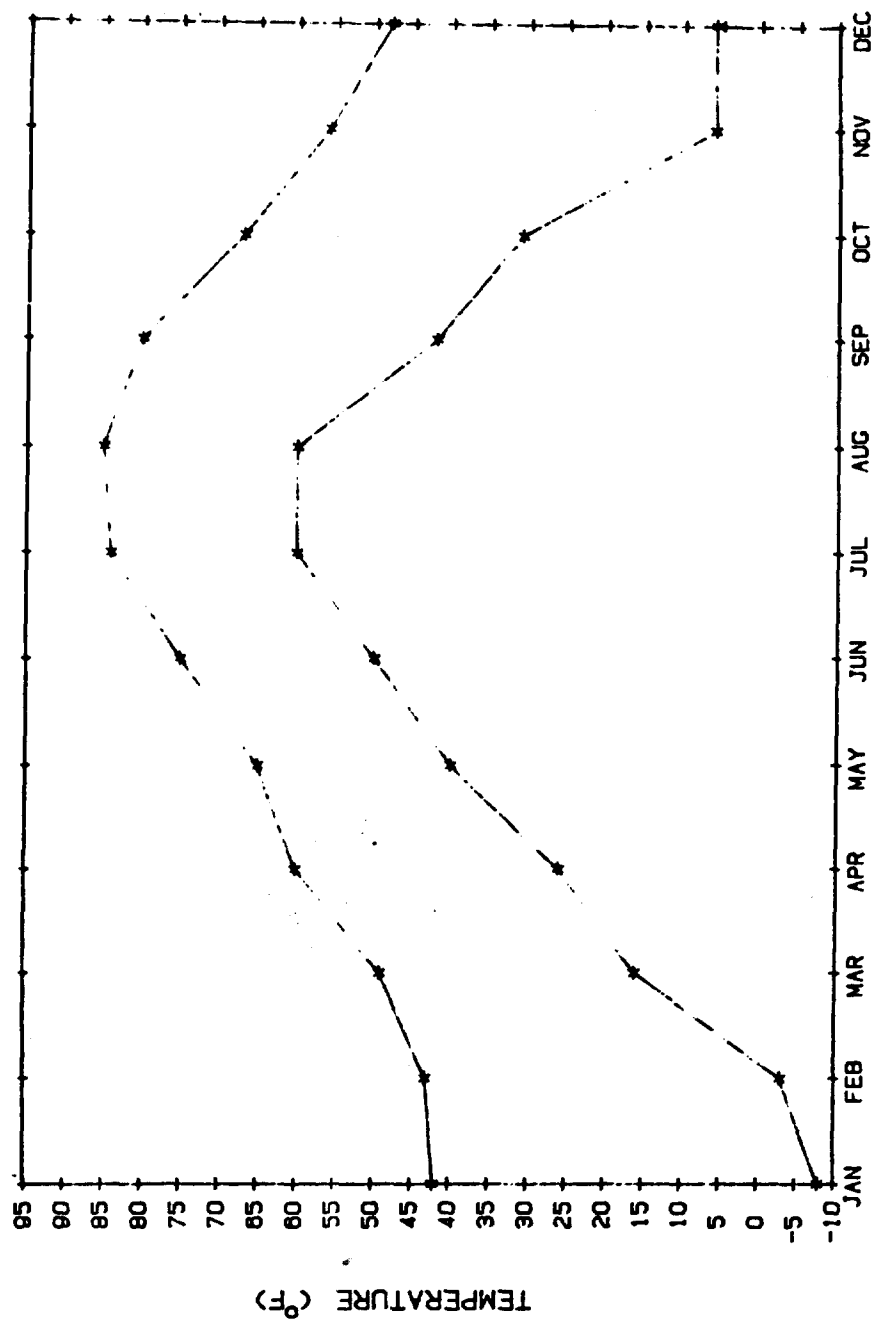


Figure A-18. Daily Minimum Temperature Range, Worst Case: Korea.

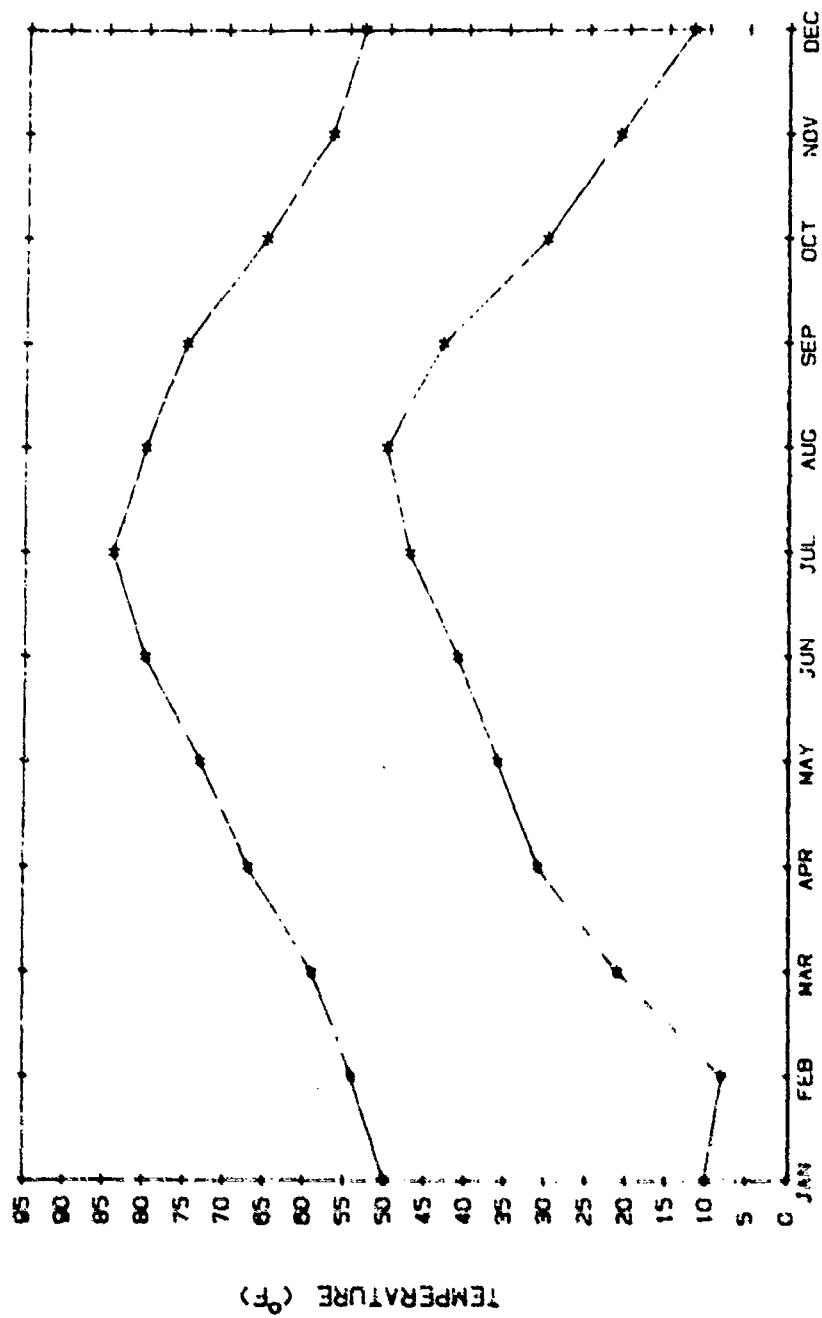


Figure A-19. Daily Mean Temperature Range, Worst Case: Korea.

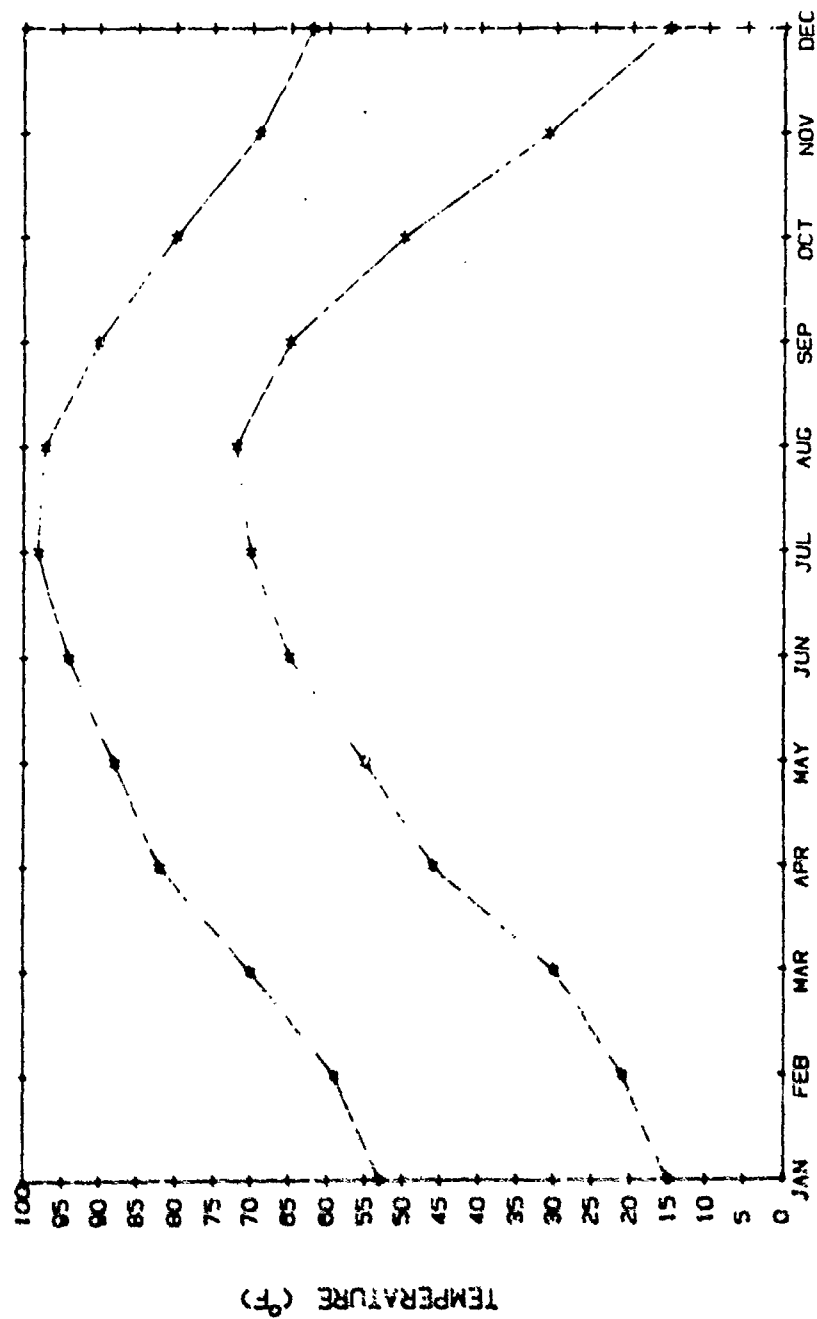


Figure A-20. Daily Maximum Temperature Range, Worst Case: Korea.

c. Frequency of Occurrence for Indicated Temperatures

This set of graphs indicates daily patterns of temperature by month. The temperature is recorded hourly for each airbase and then is grouped into the intervals indicated on the graphs. These statistics were determined by calculating the percentage of those recorded values that fall within each temperature range. The resulting percentage frequencies were averaged across each theater.

EXAMPLE 1: In January at Upper Heyford (Figure A-21), 11 percent of temperatures from 9:00 a.m. to 11:00 a.m. range from 0°F to 32°F; the rest of the time (89 percent of the recorded values), the temperature is between 32°F and 67°F.

EXAMPLE 2: Consider the Korean theater in July (Figure A-39) from 12:00 a.m. to 2:00 a.m. During these hours, approximately 14 percent of the temperatures were between 32°F and 67°F, 76 percent of the temperatures were between 67°F and 80°F, and 10 percent of the temperatures were greater than 80°F.

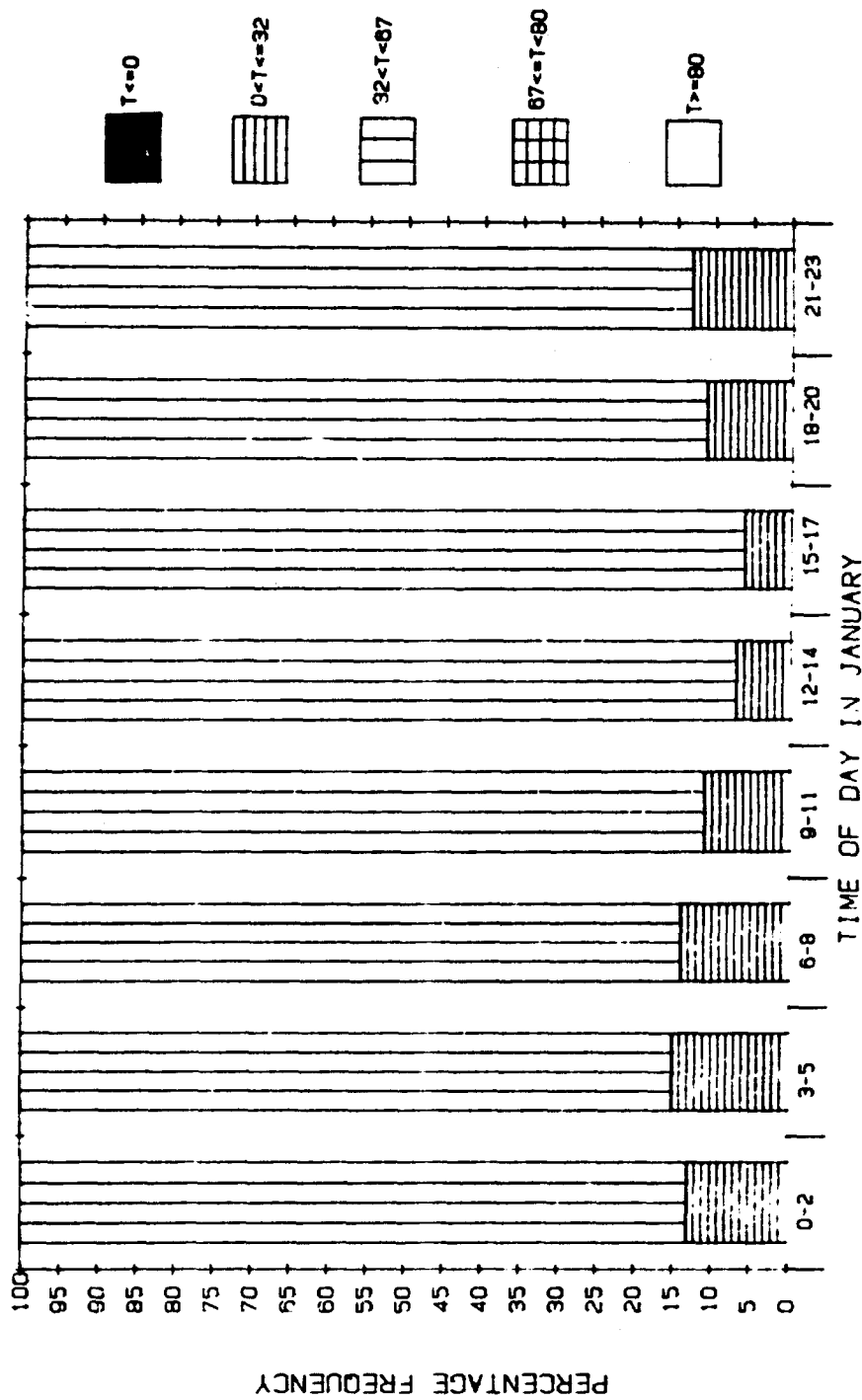


Figure A-21. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

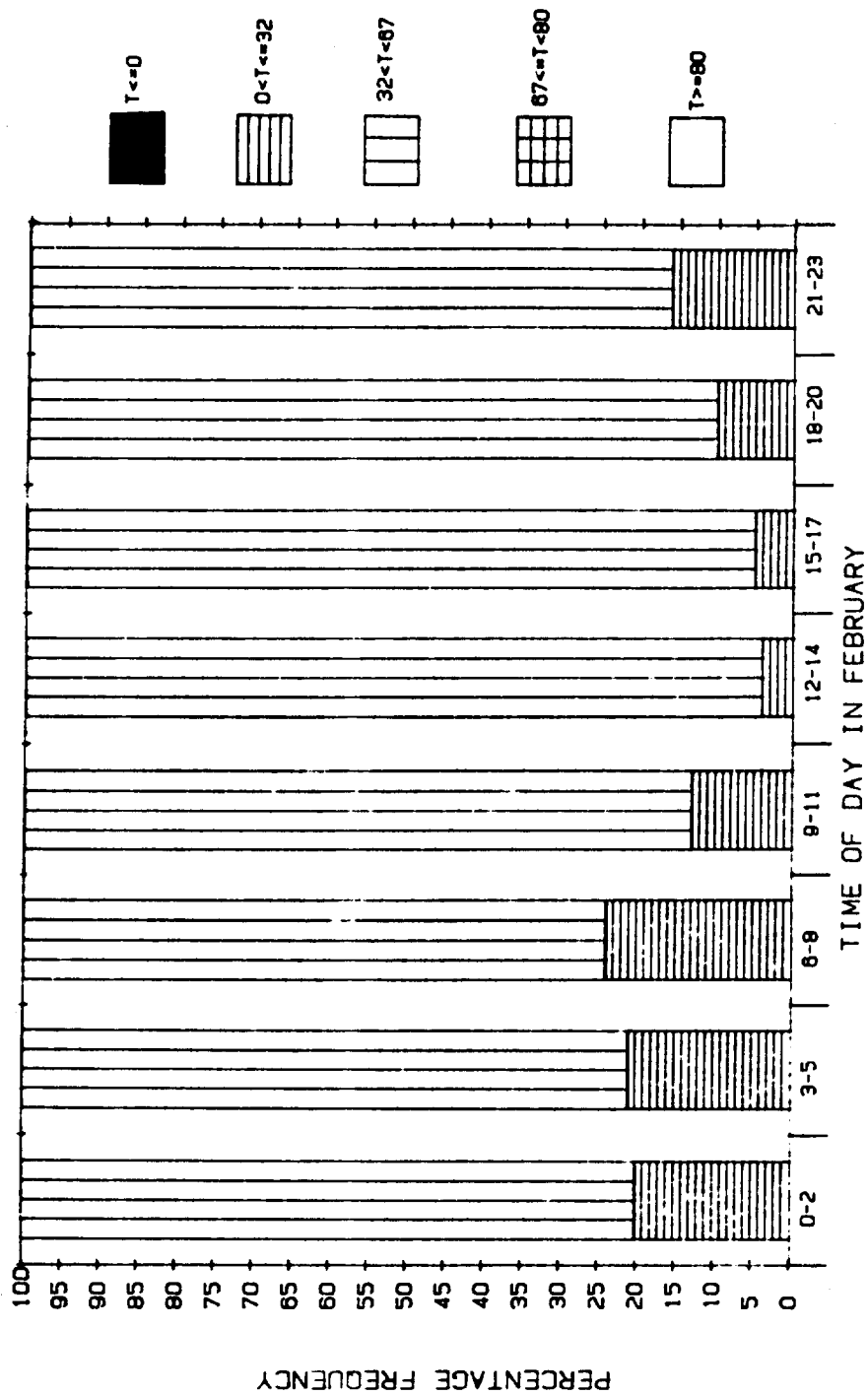


Figure A-22. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

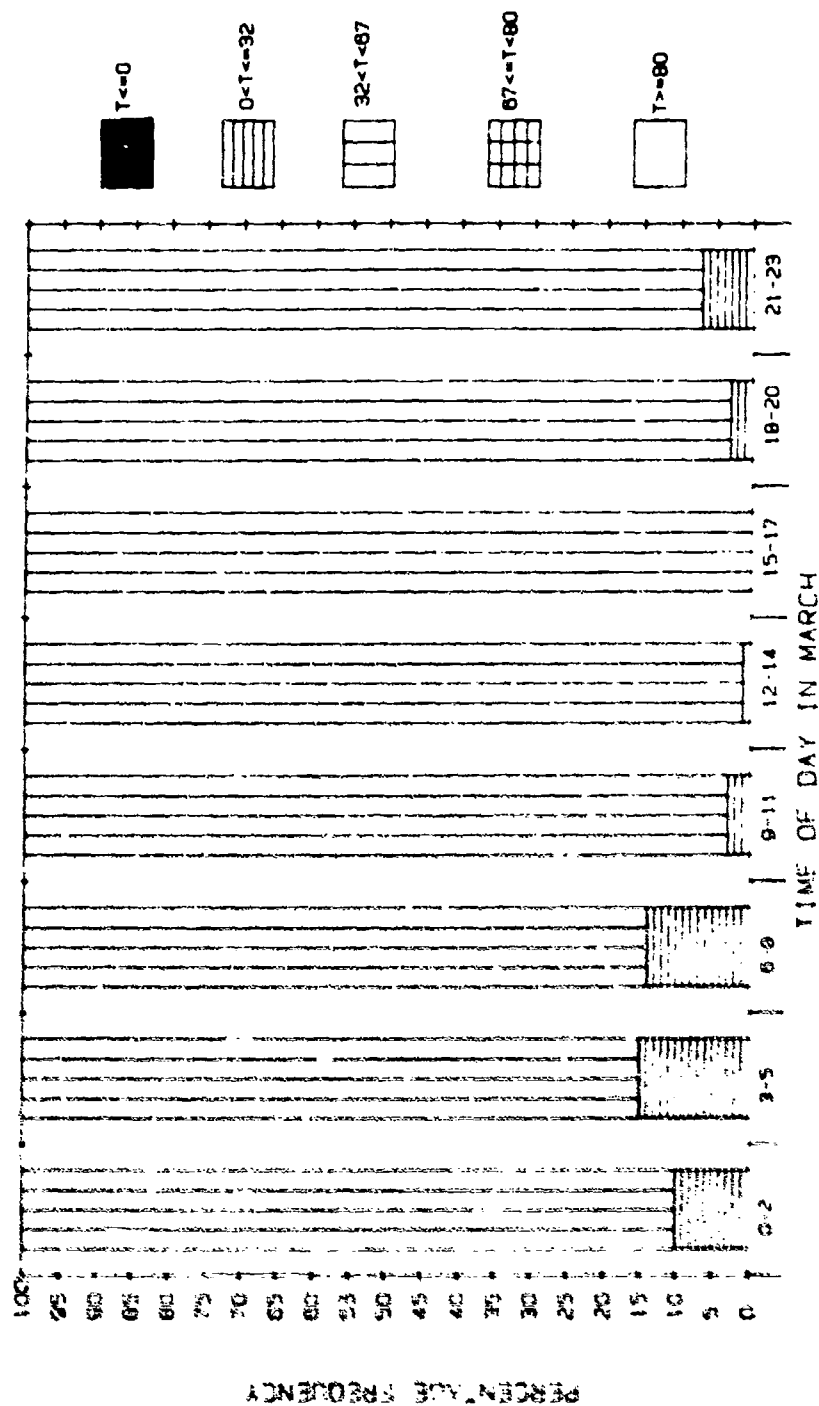


Figure A-23. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.

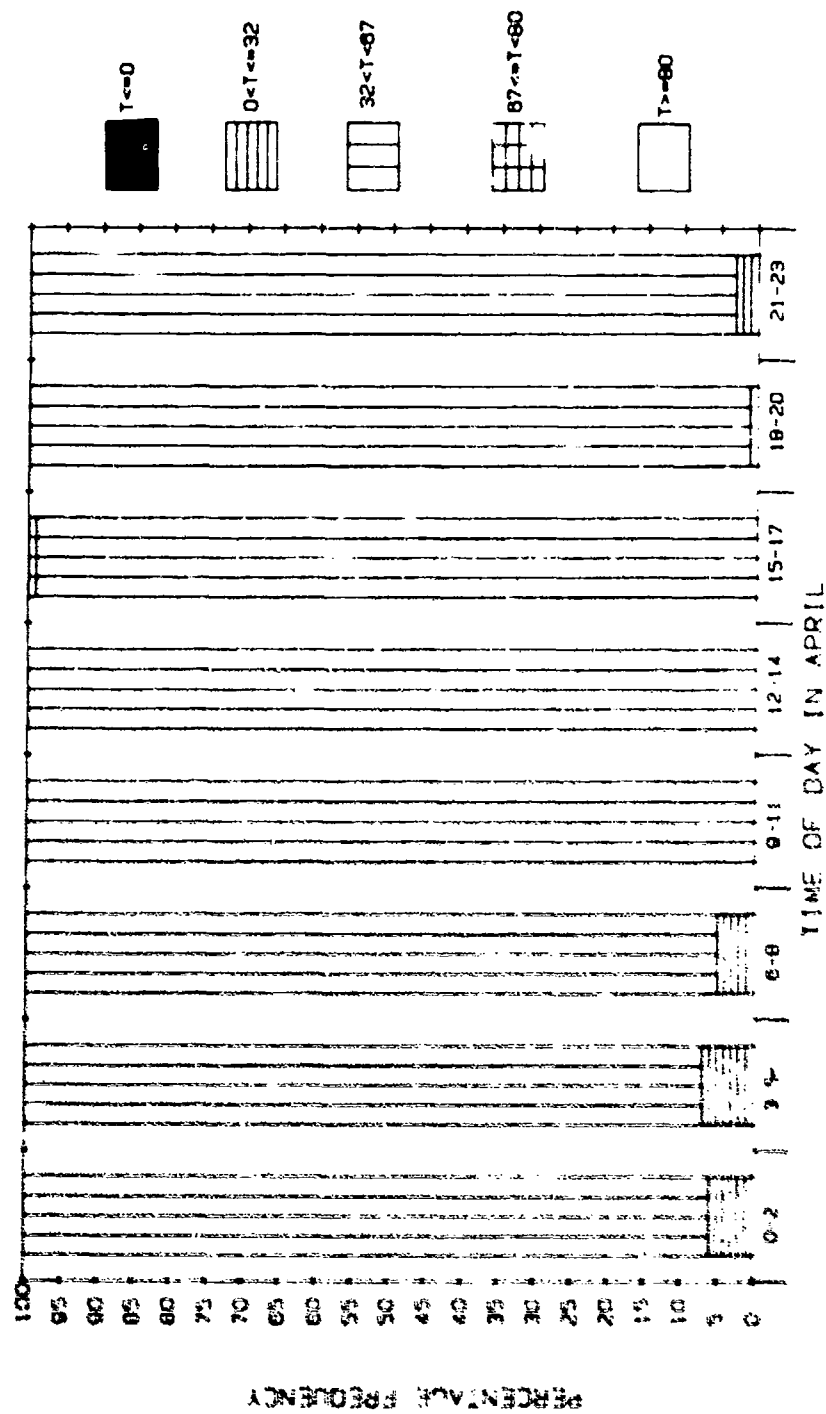


Figure A-24. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

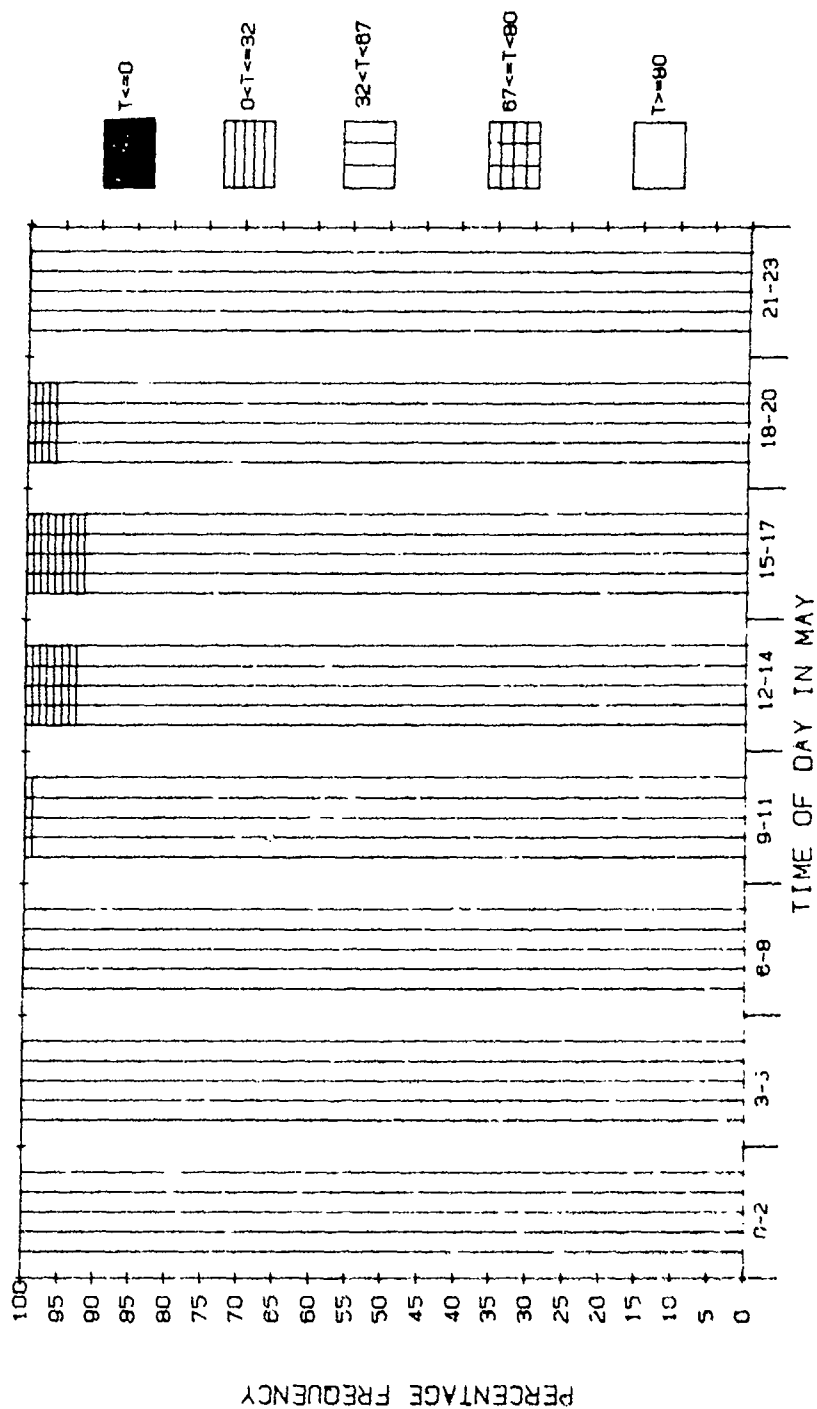


Figure A-25. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

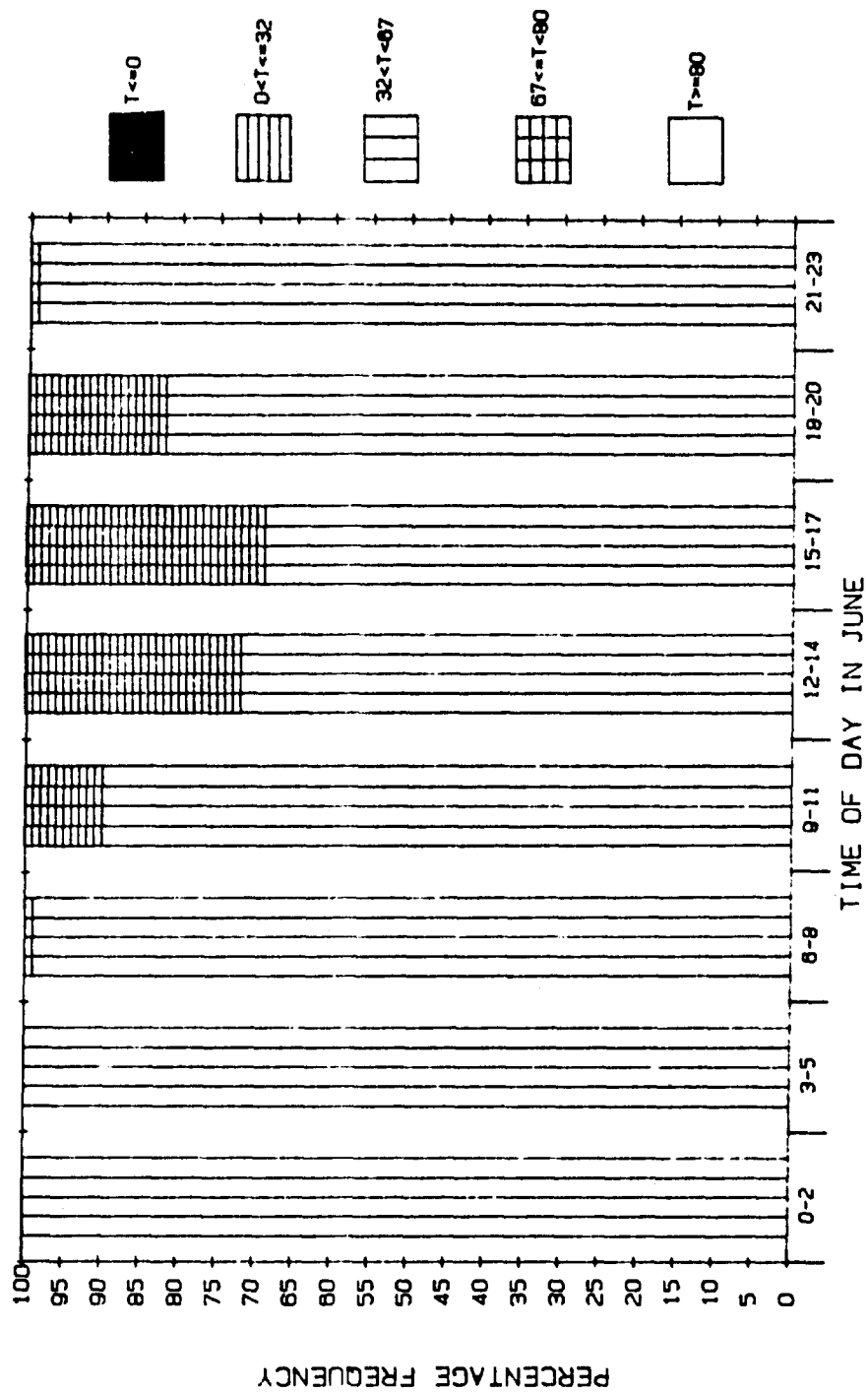


Figure A-26. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

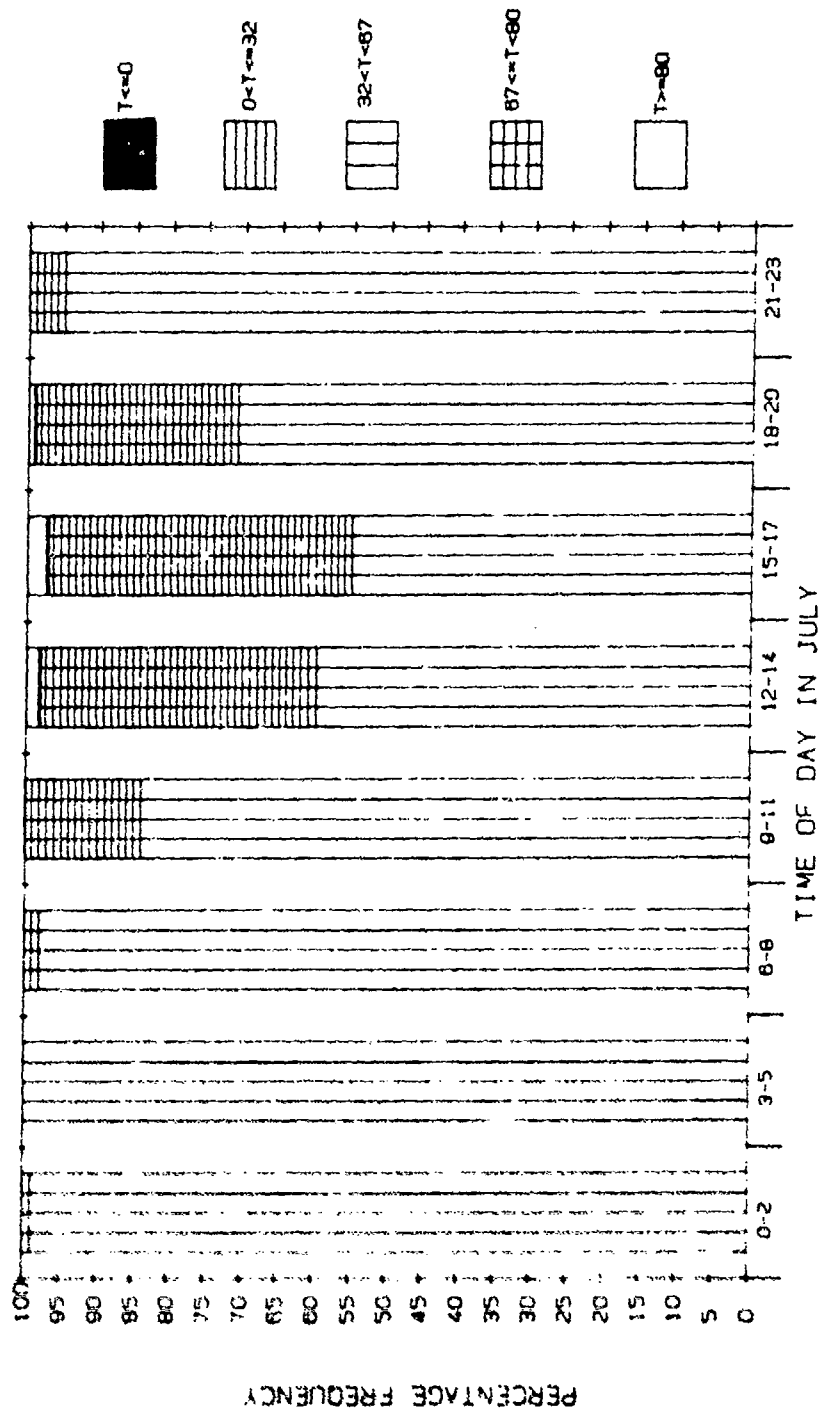


Figure A-27. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.

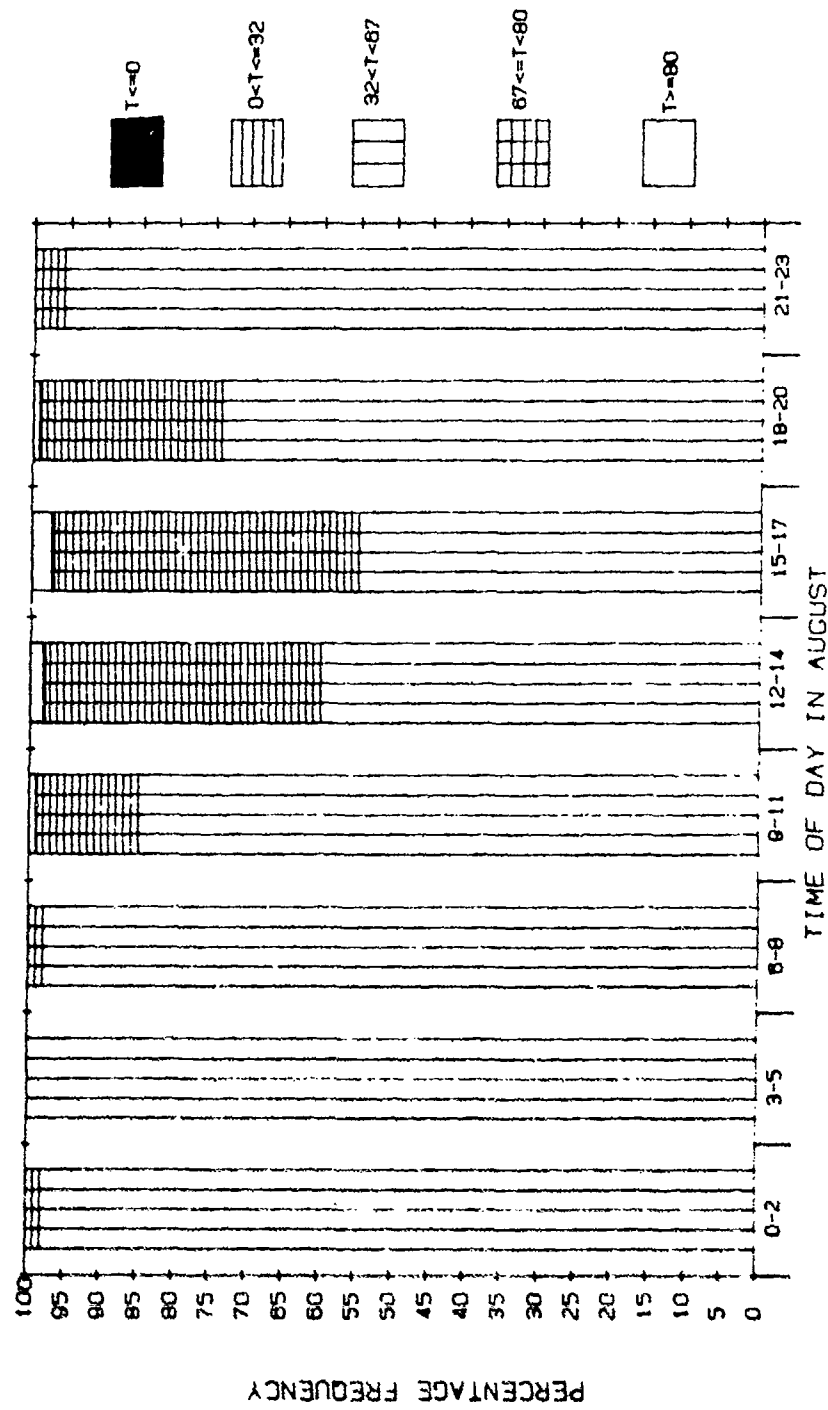


Figure A-28. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

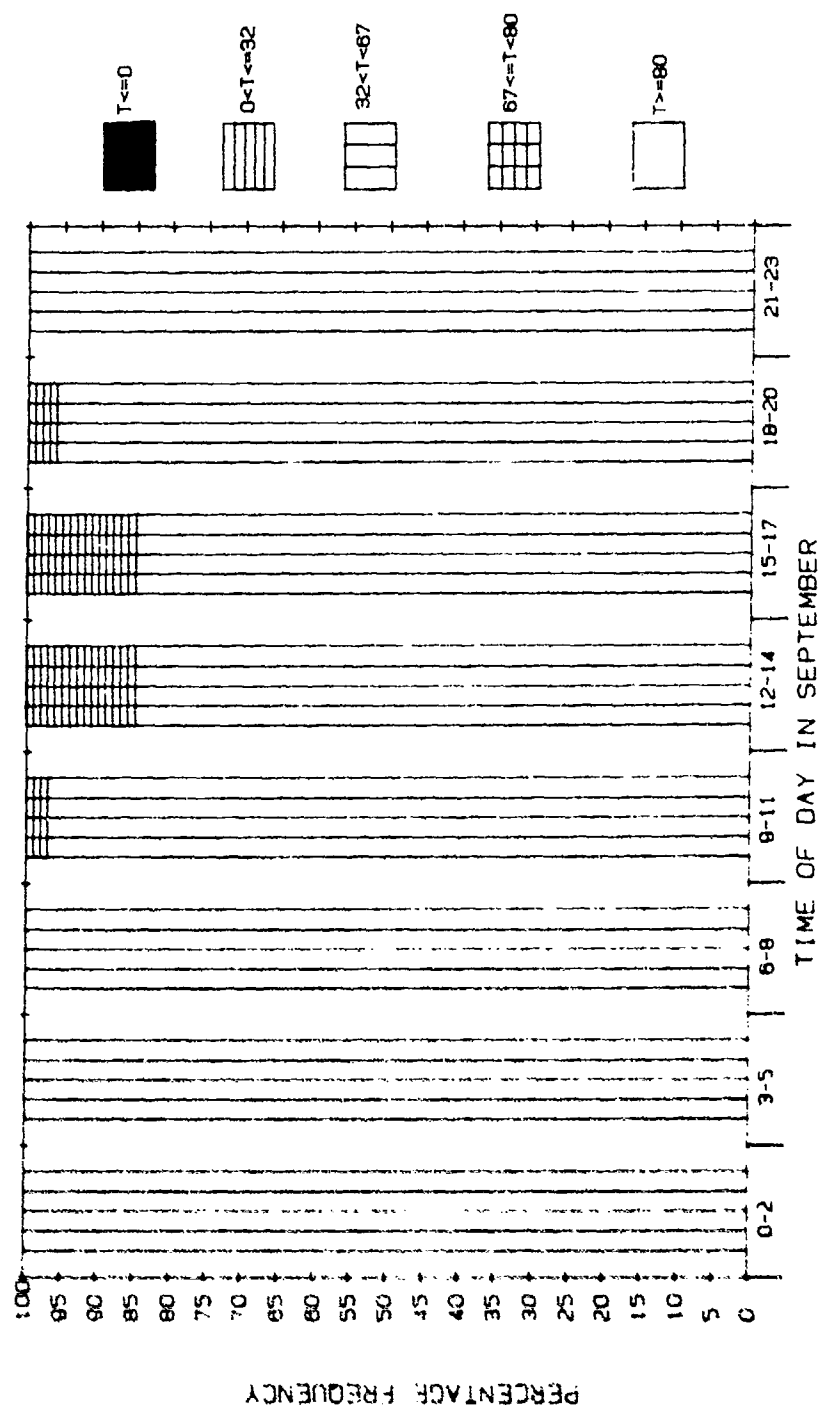


Figure A-29. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

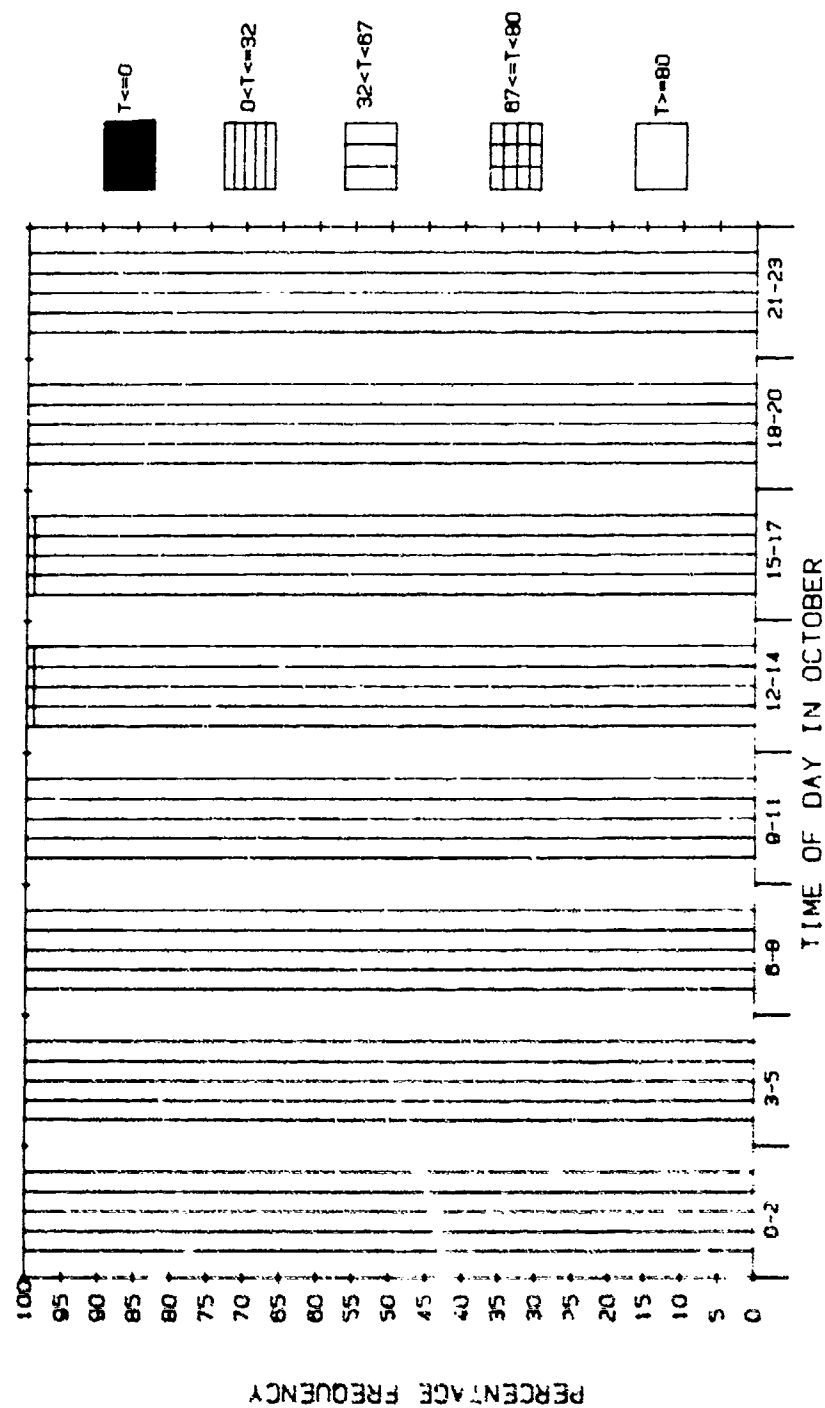


Figure A-30. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

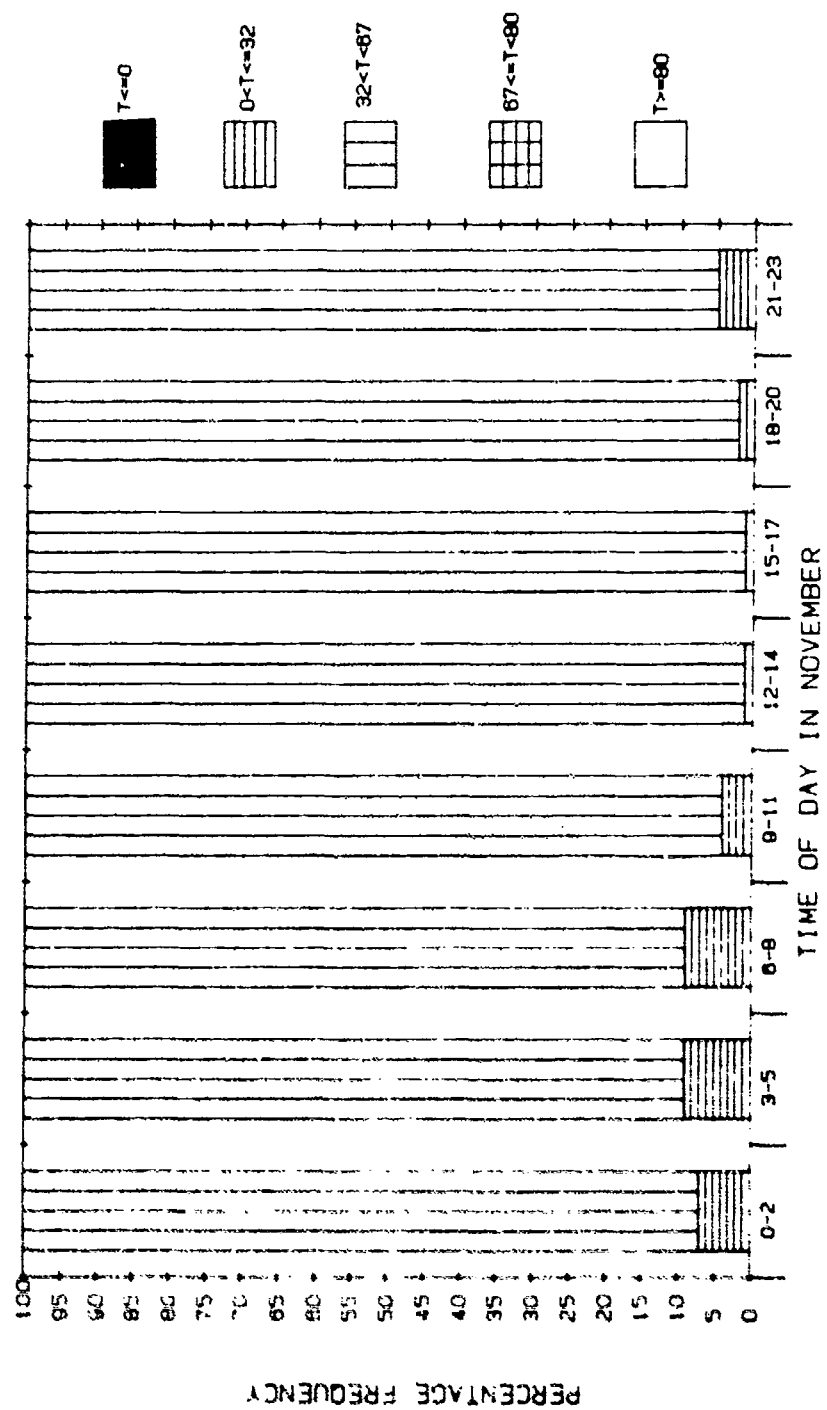


Figure A-31. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Upper Heyford.

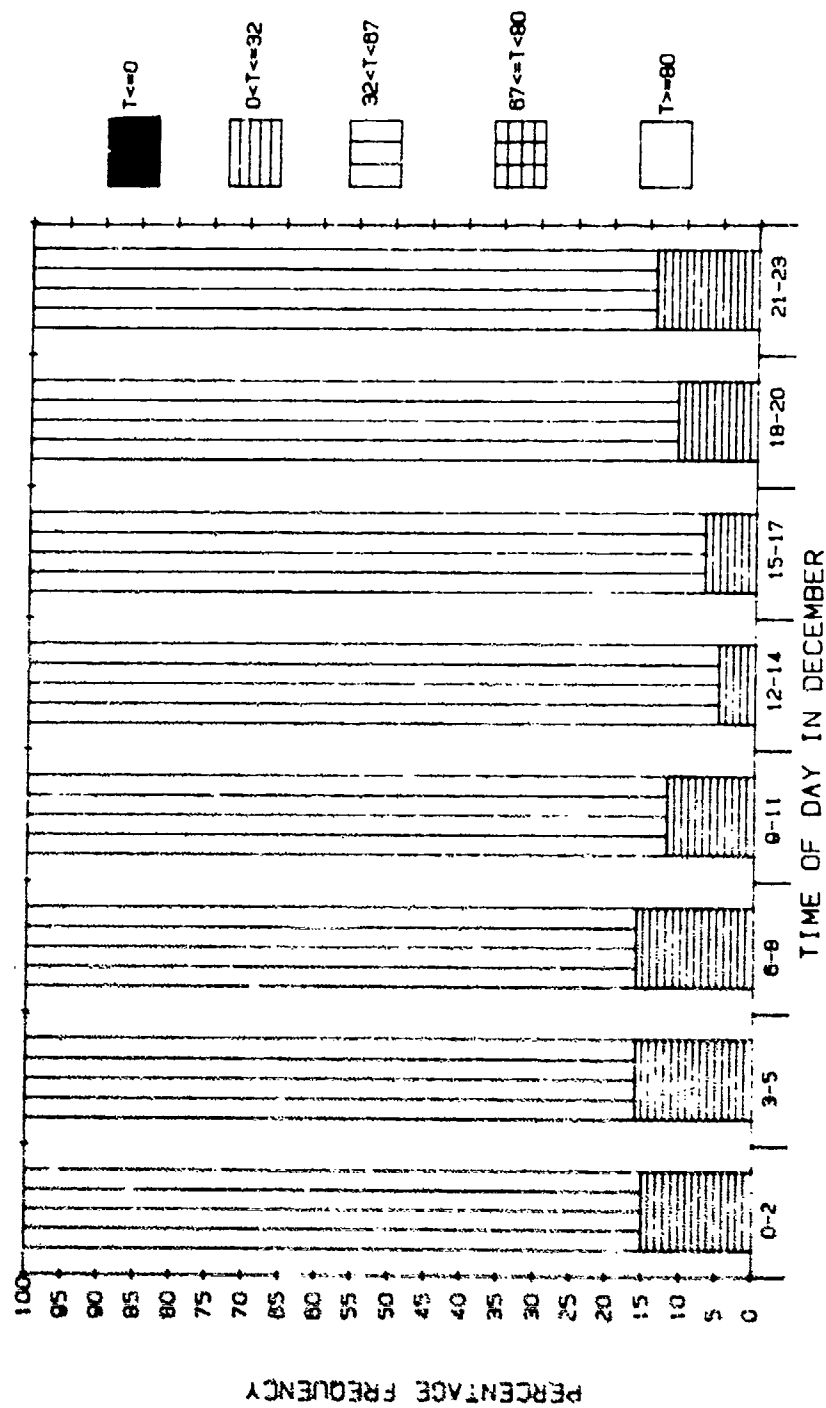


Figure A-32. Frequency of Occurrence for Temperature (T °F), Upper Heyford.

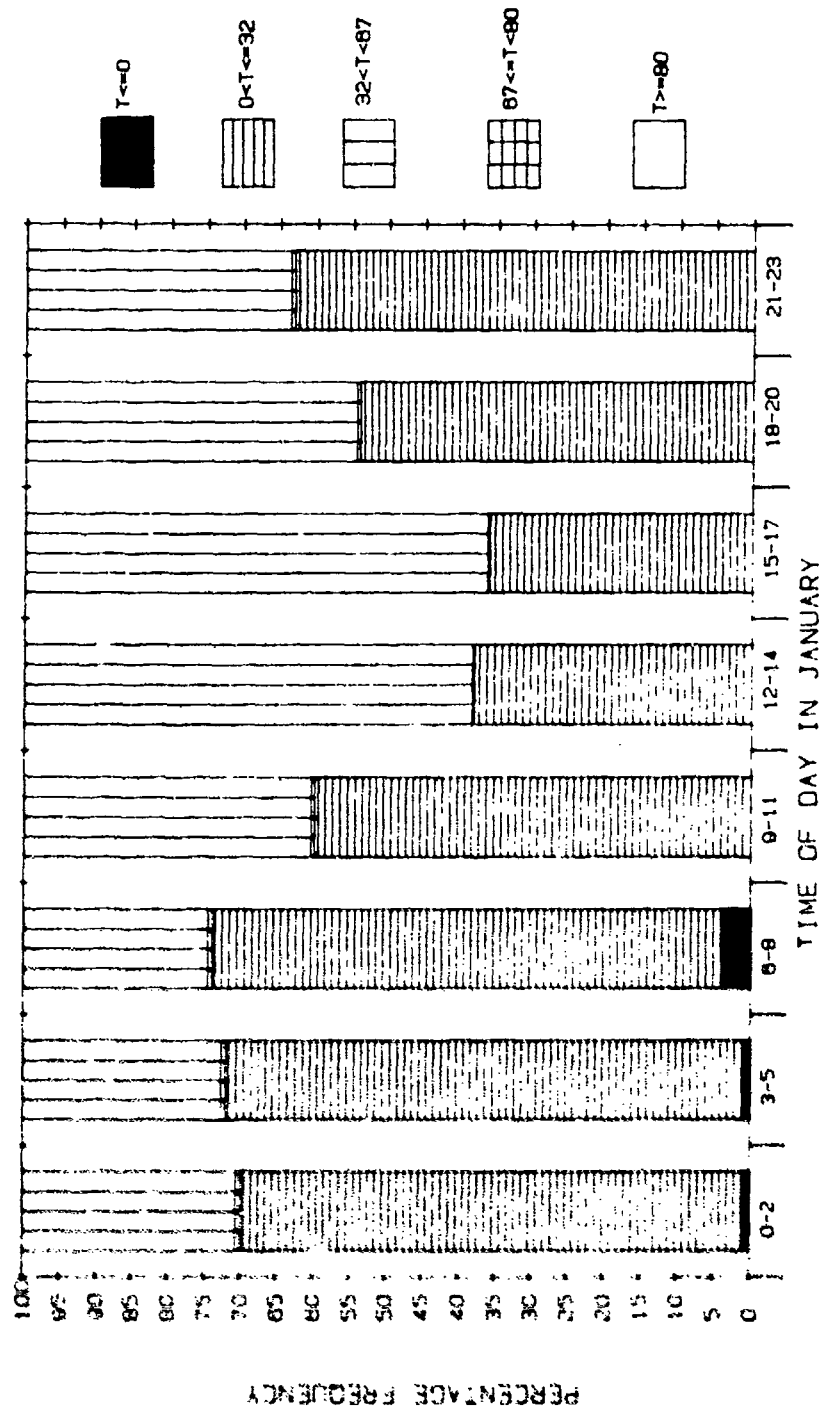


Figure A-33. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

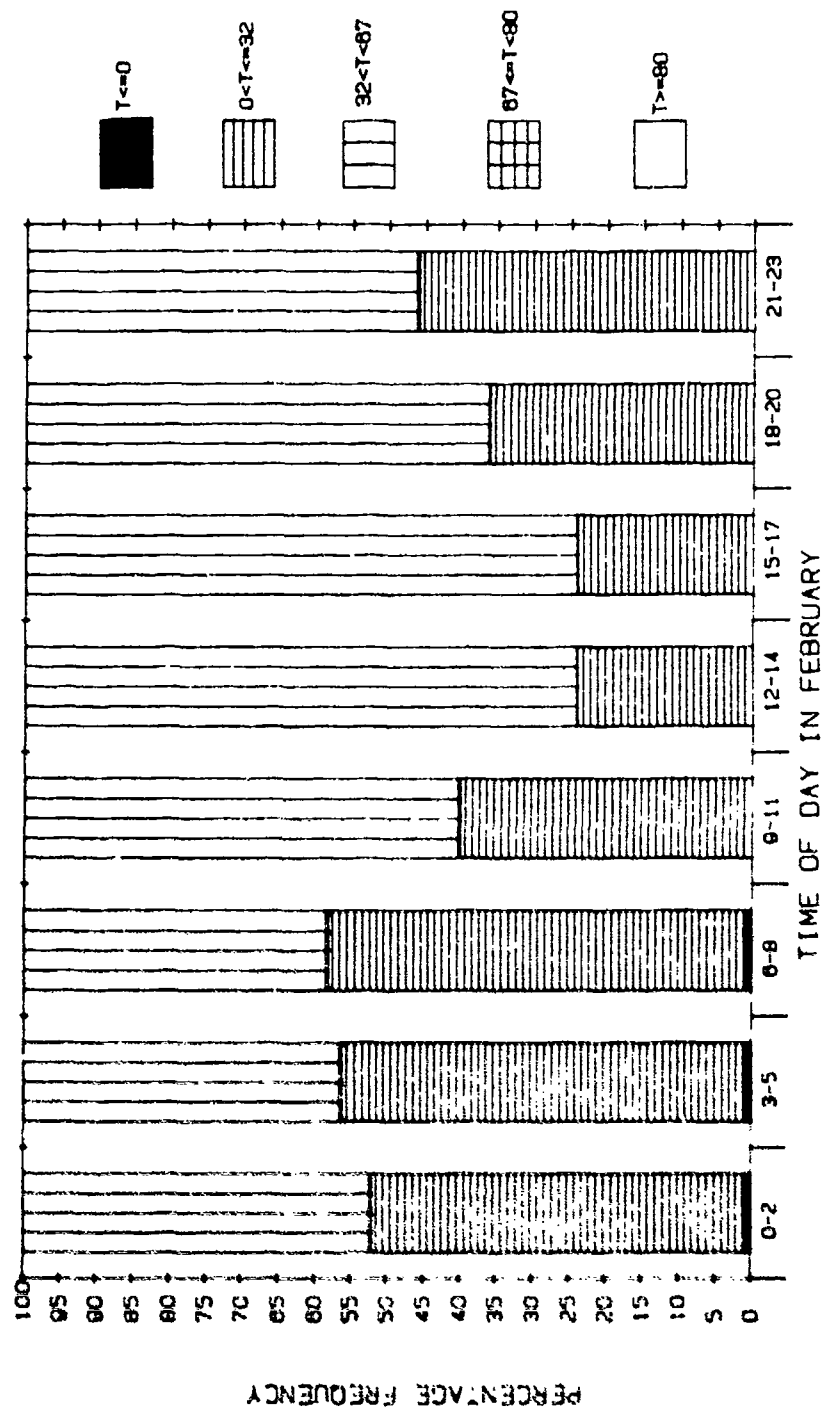


Figure A-34. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

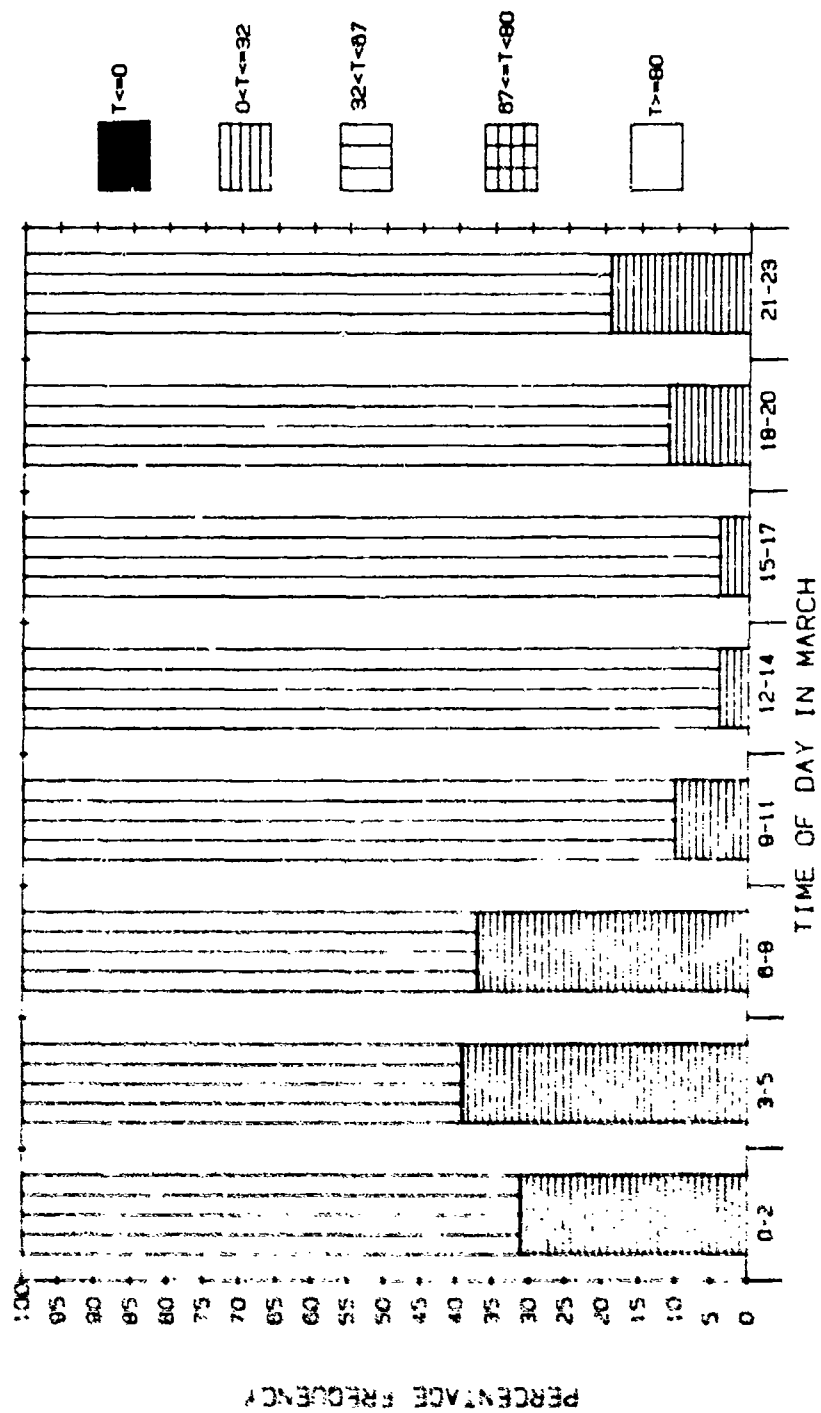


Figure A-35. Frequency of Occurrence for Temperature ($T^{\circ}F$), Mean of Korean Airbases.

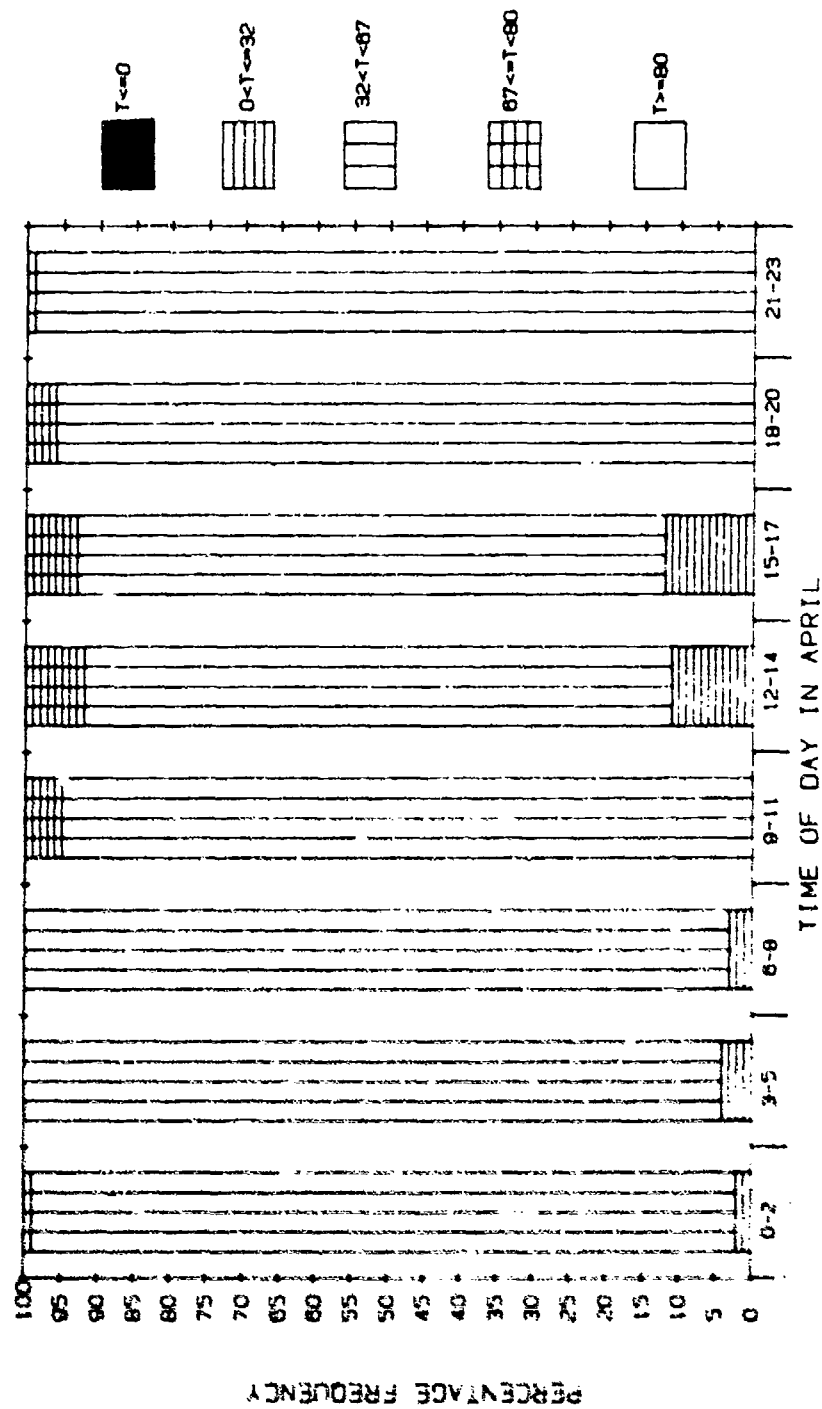


Figure A-36. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

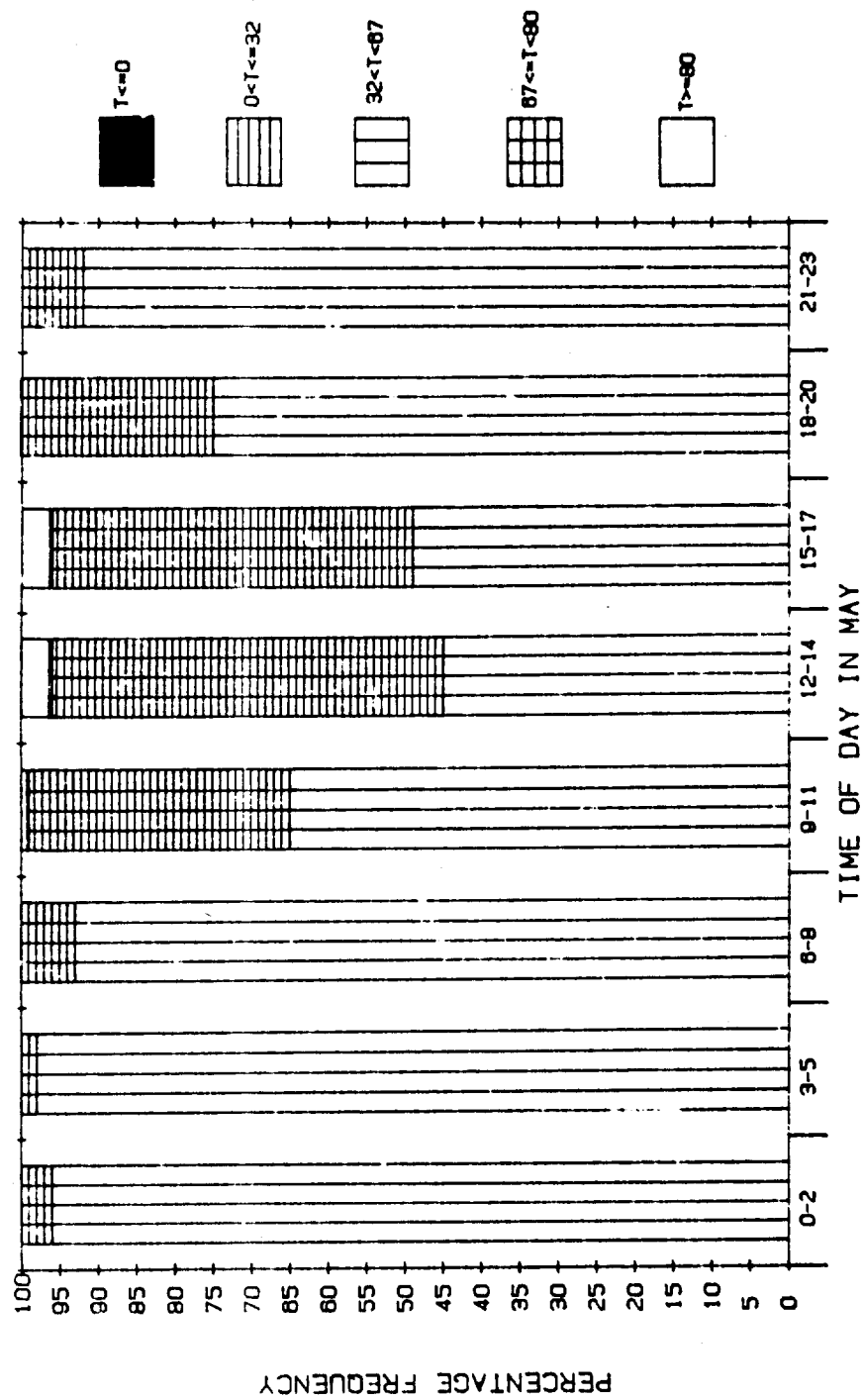


Figure A-37. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases

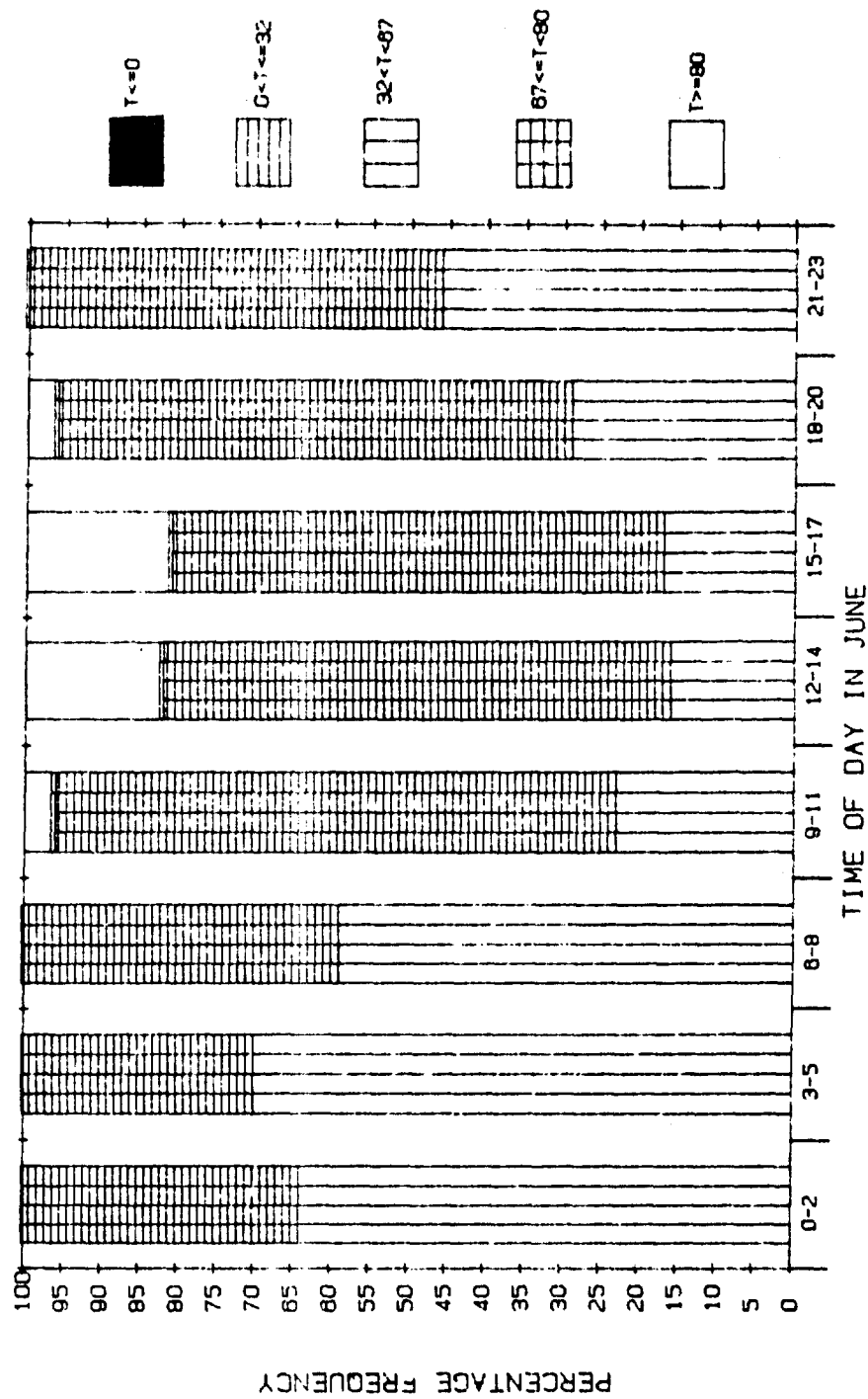


Figure A-38. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

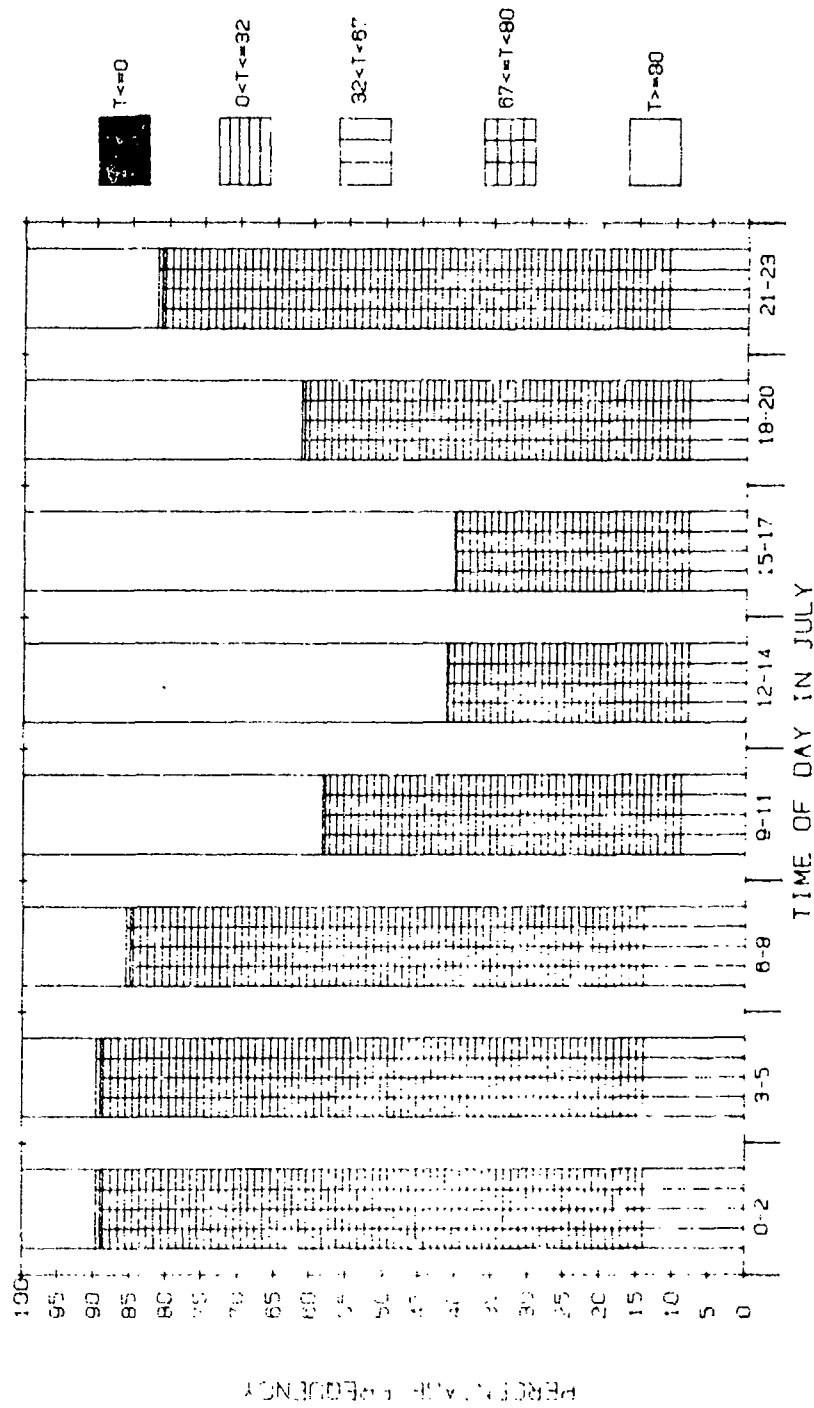


Figure A-39. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

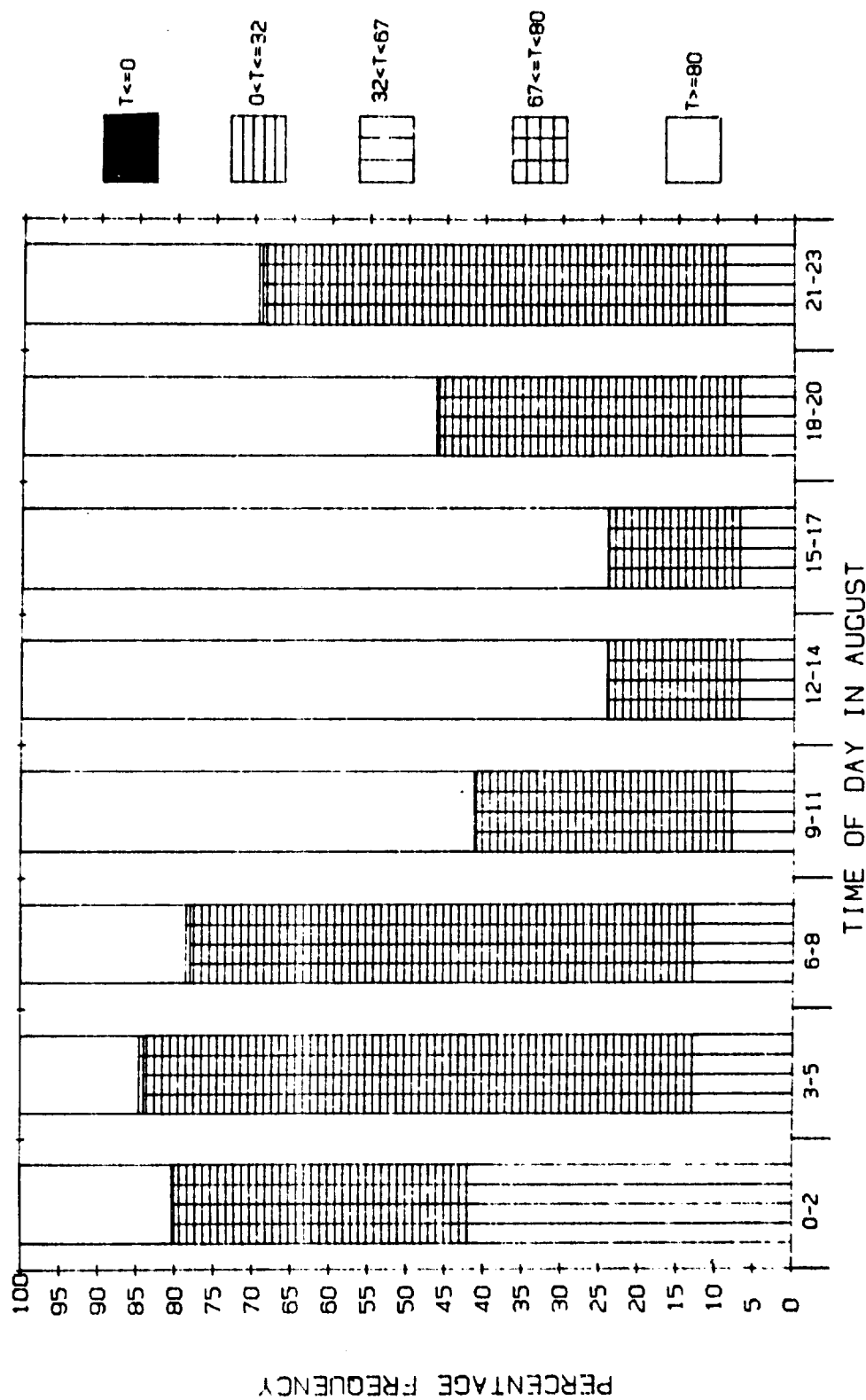


Figure A-40. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

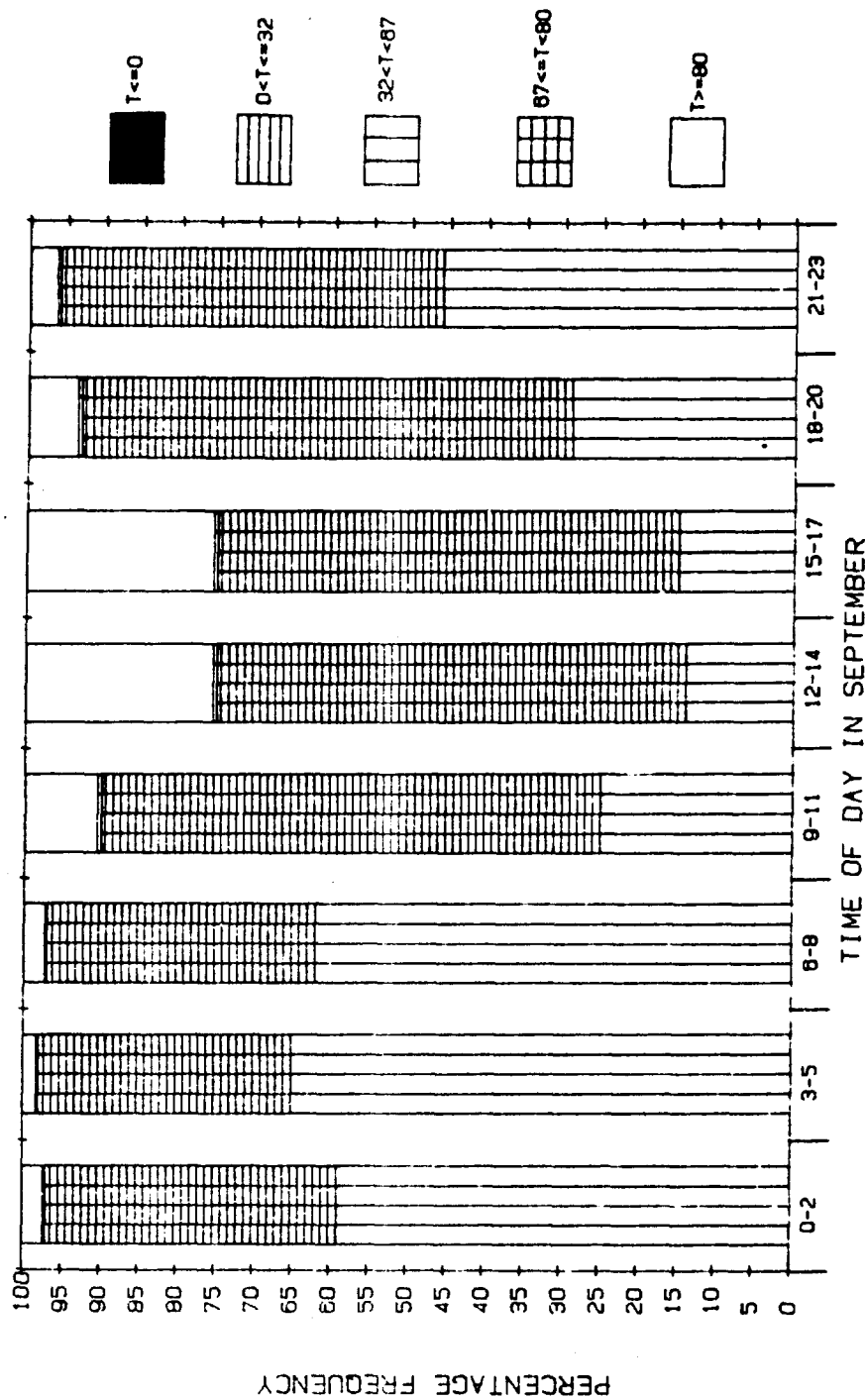


Figure A-41. Frequency of Occurrence for Temperature (T °F), Mean of Korean Airbases.

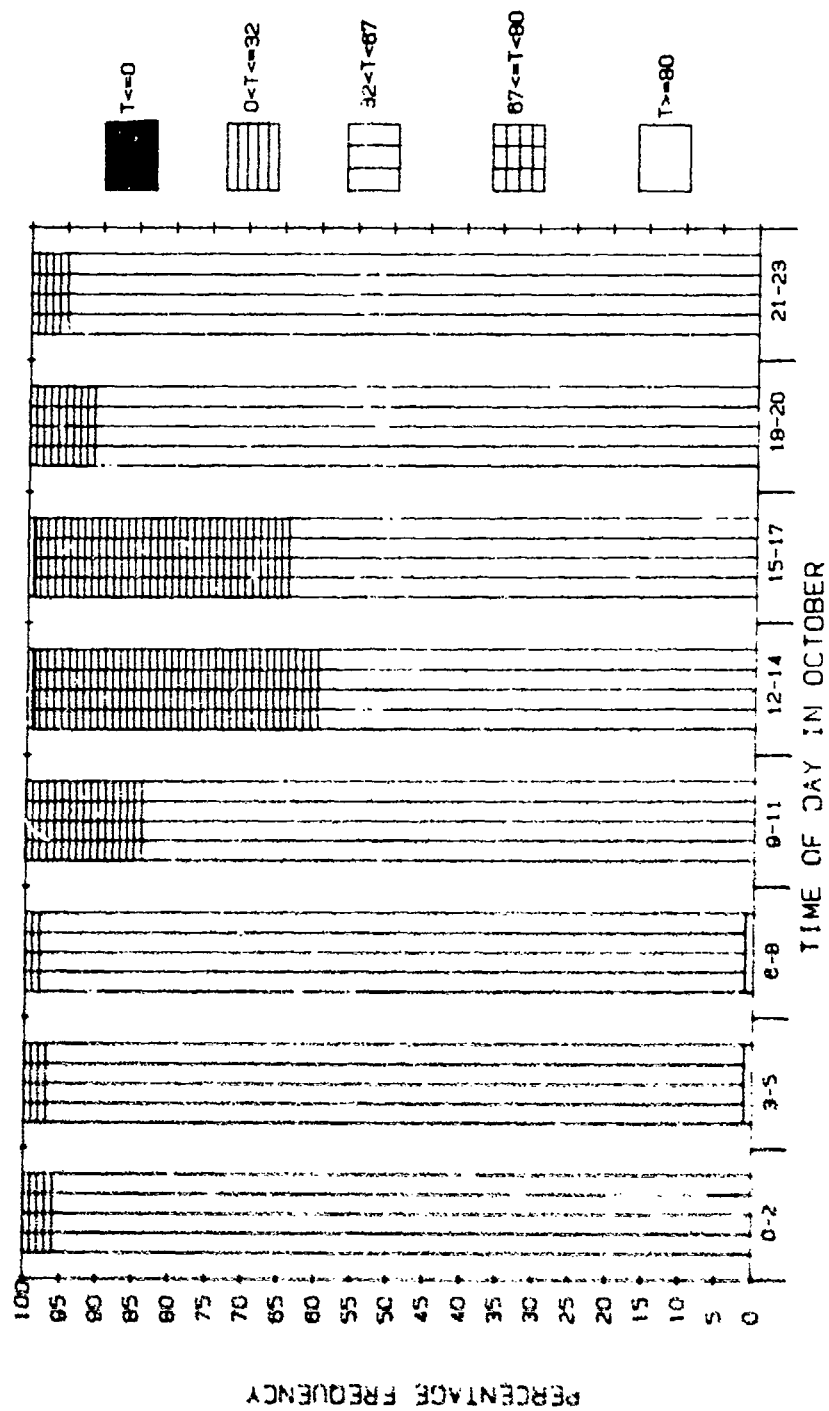


Figure A-42. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

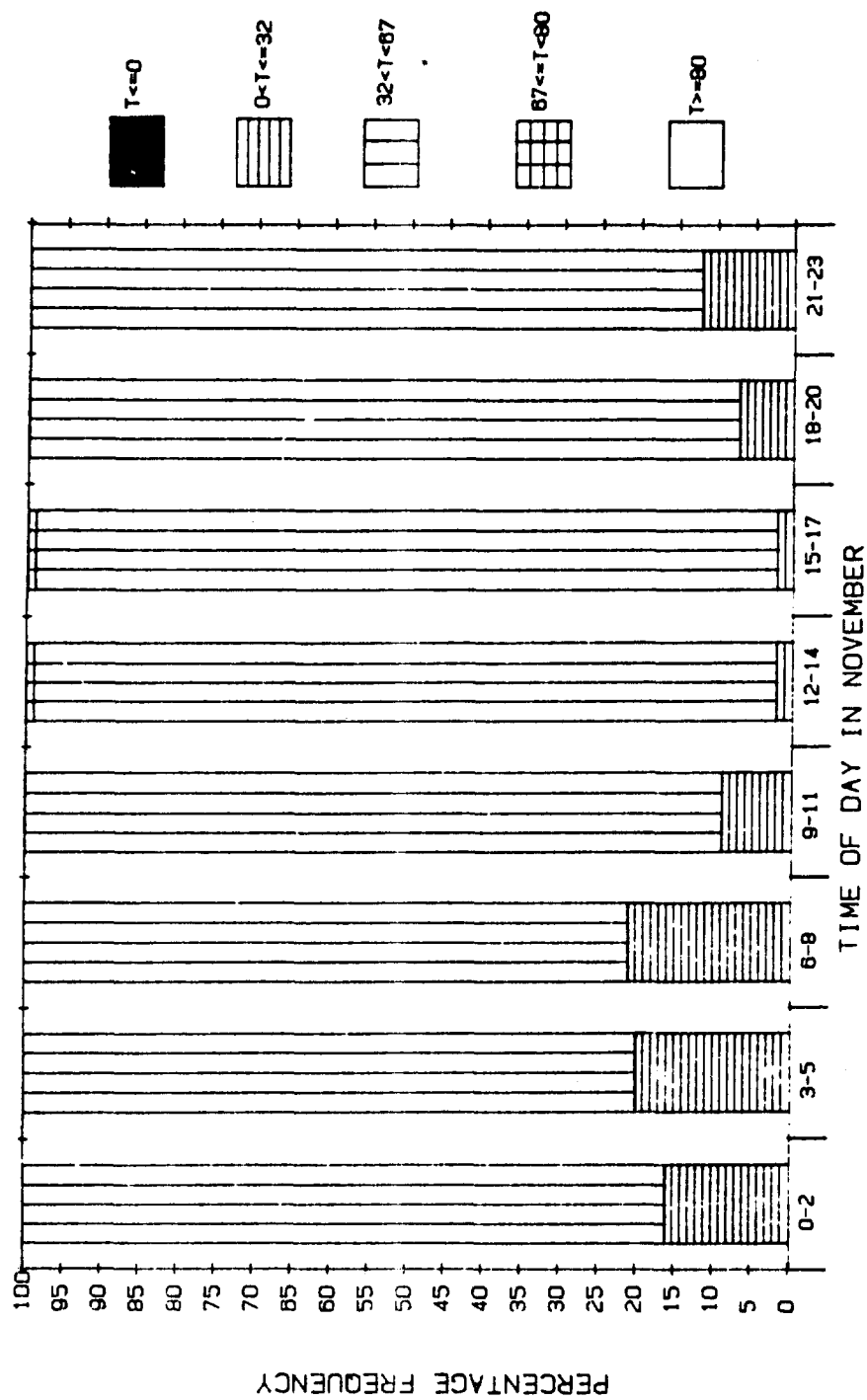


Figure A-43. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

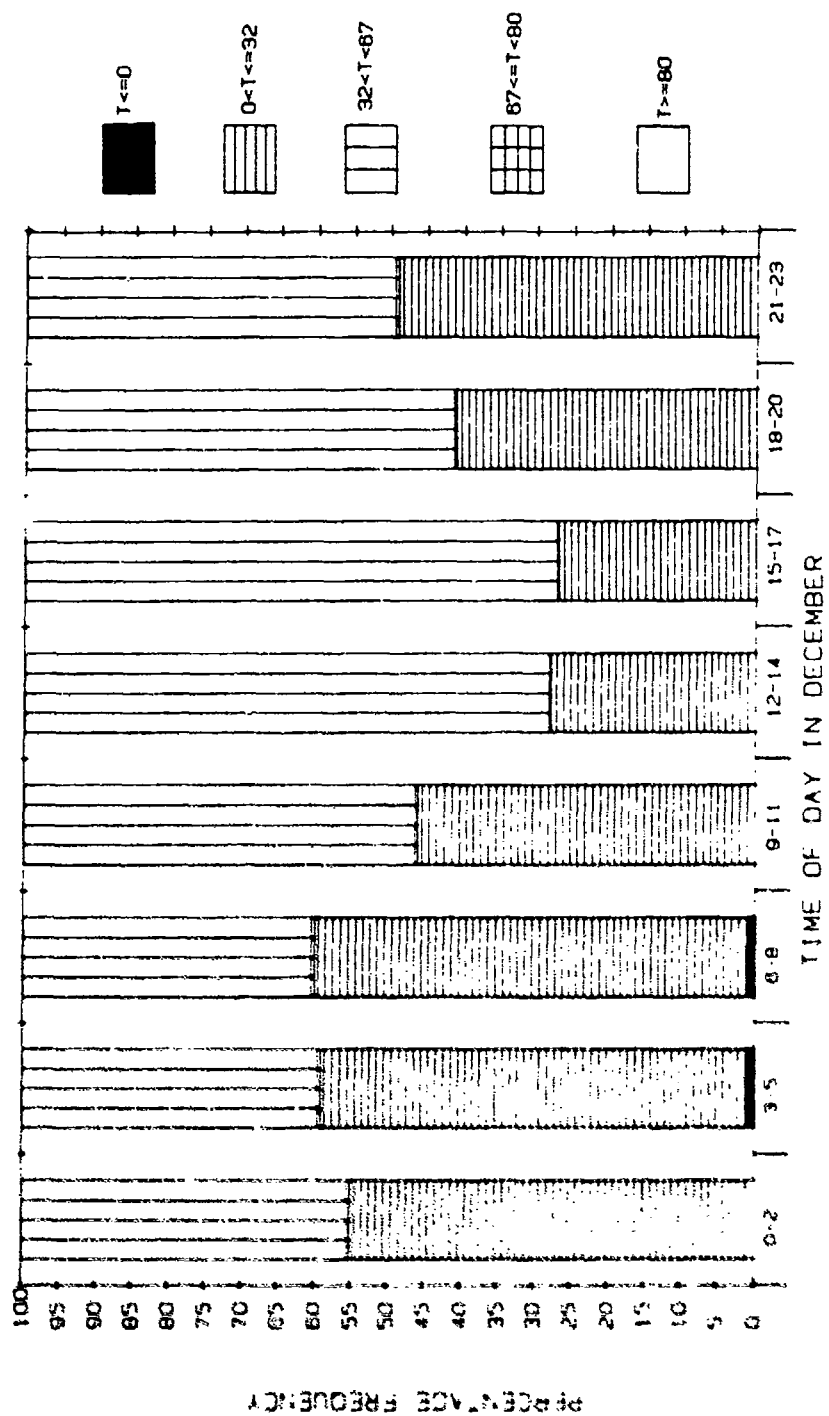


Figure A-44. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of Korean Airbases.

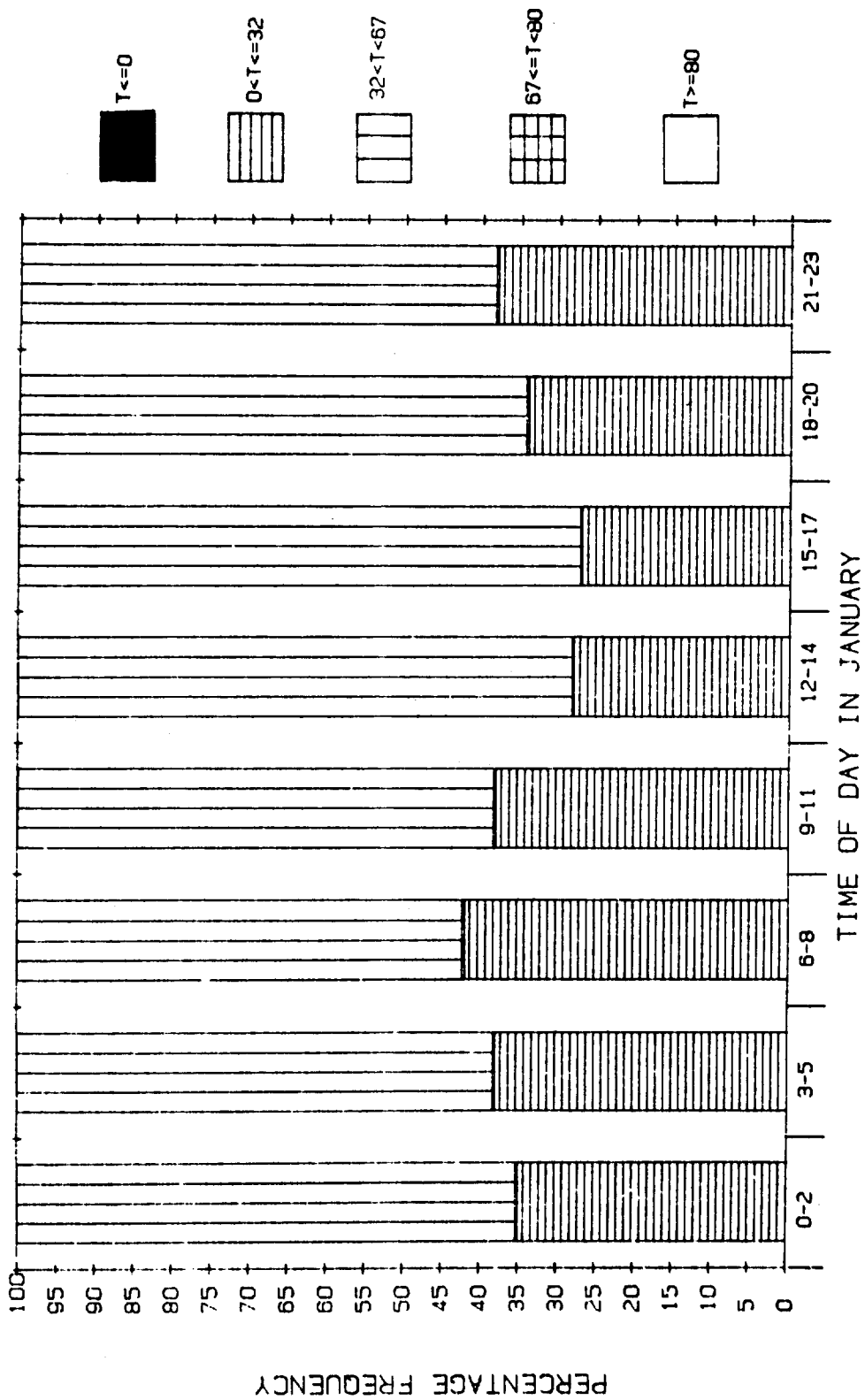


Figure A-45. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

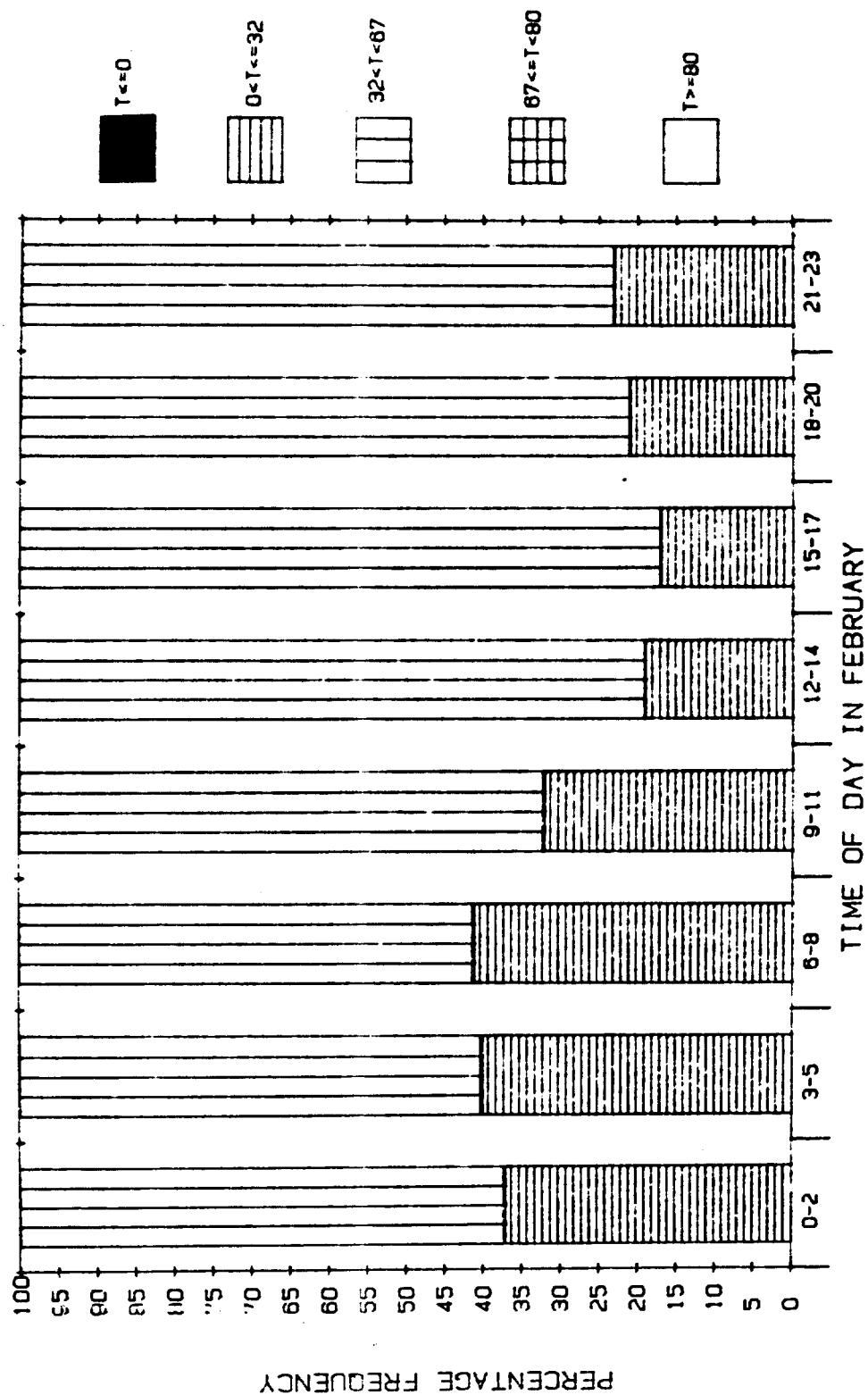


Figure A-46. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

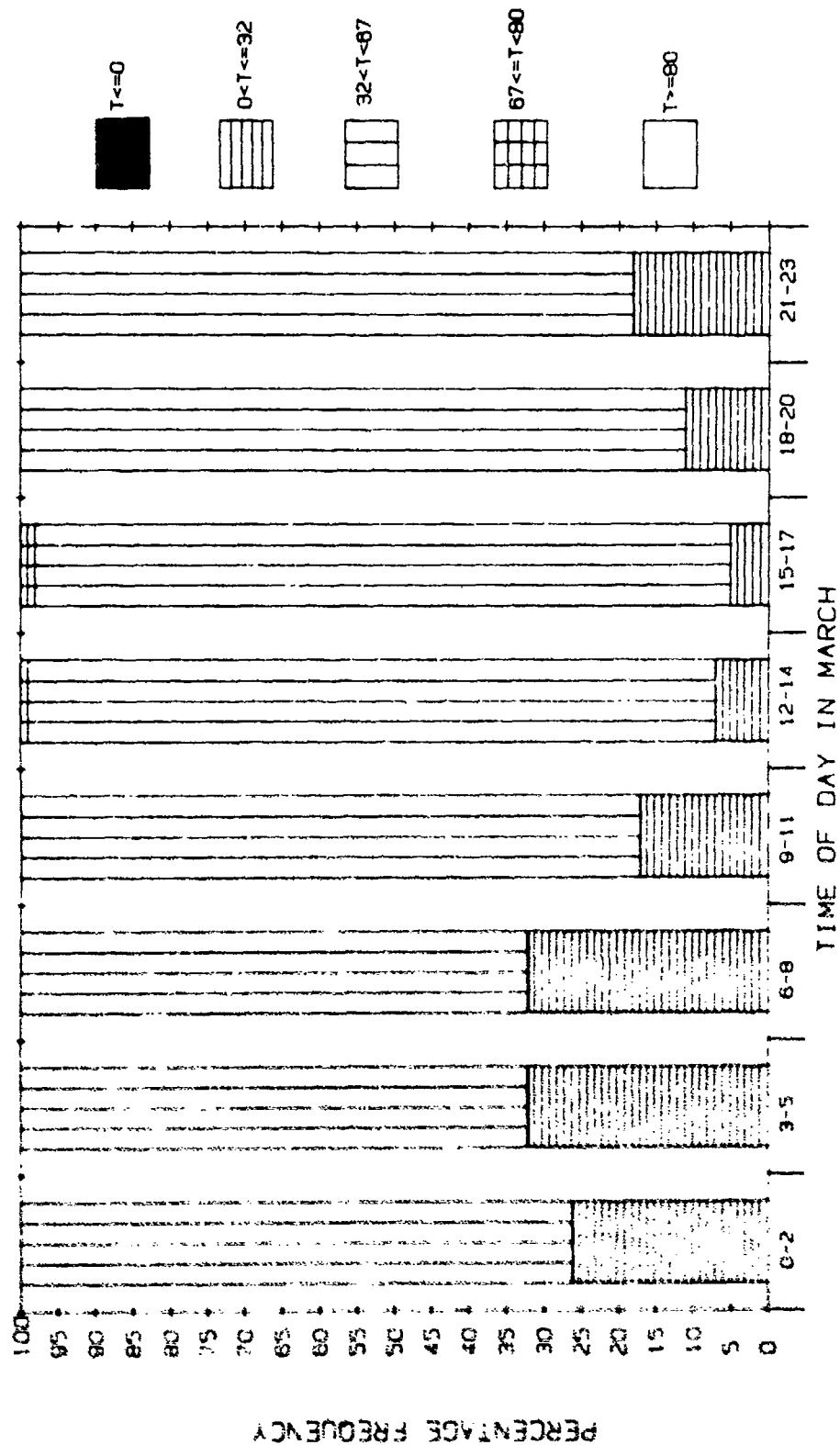


Figure A-47. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

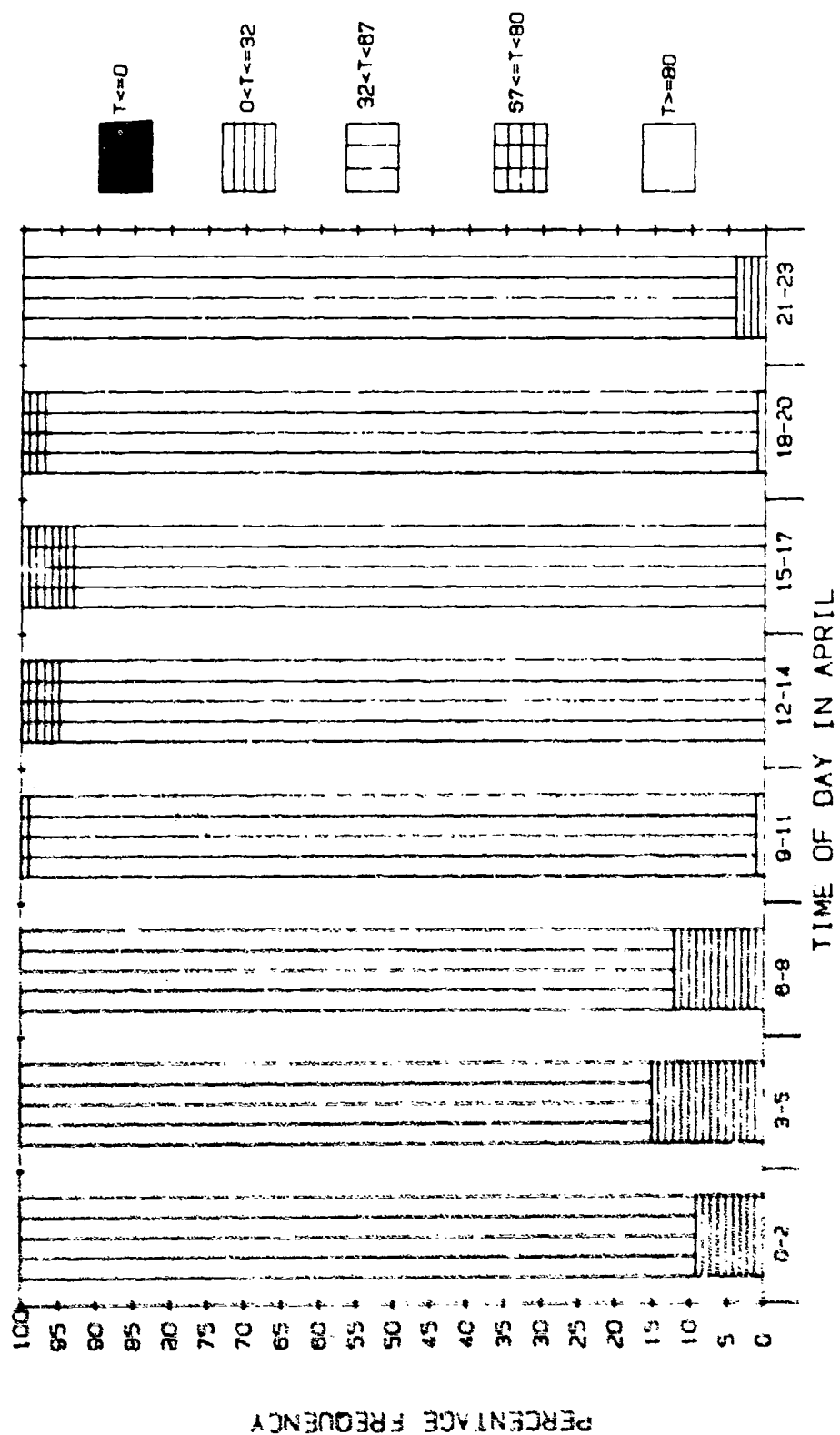


Figure A-48. Frequency of Occurrence for Temperature (T °F), Mean of German Airbases.

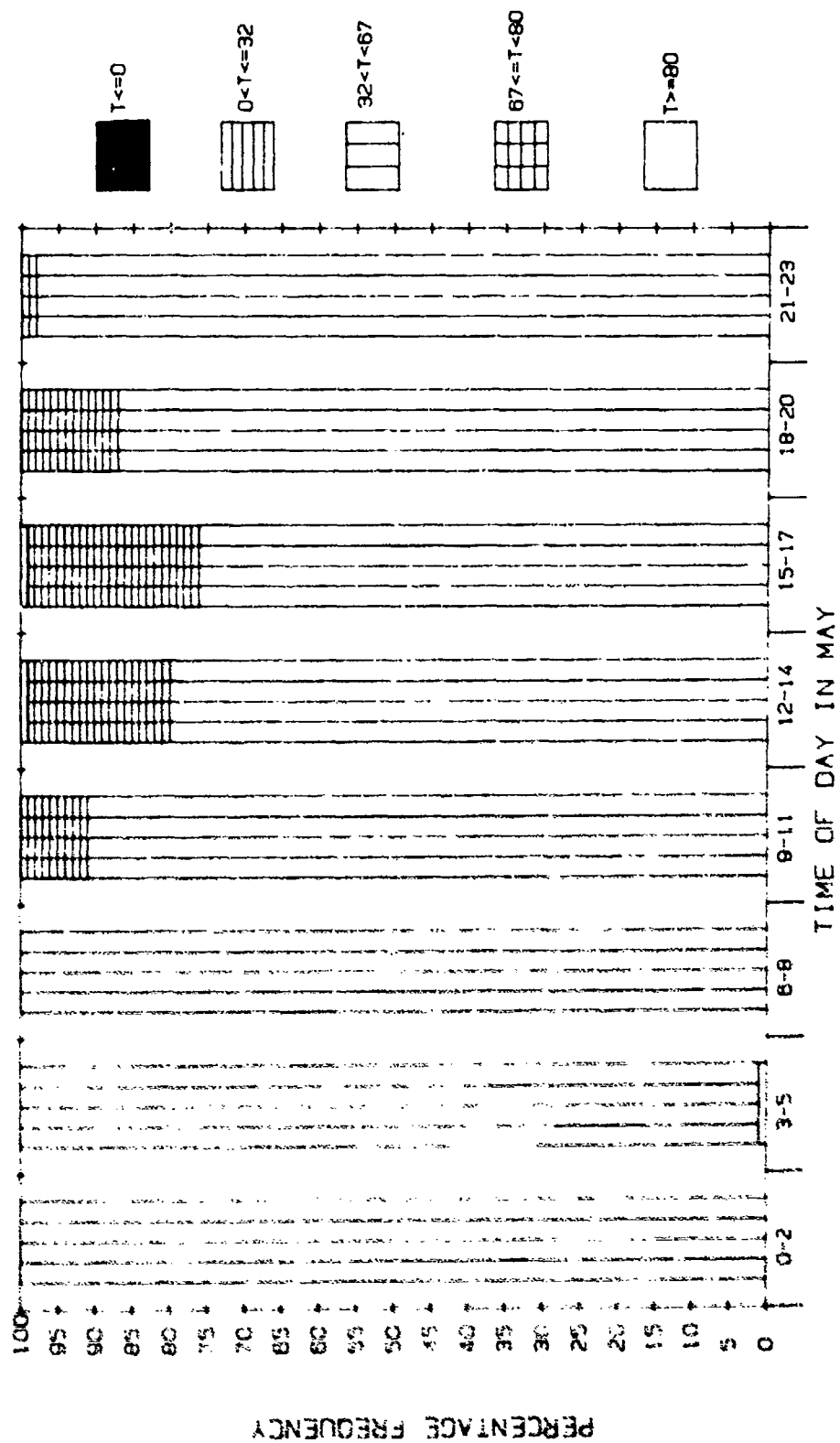


Figure A-49. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

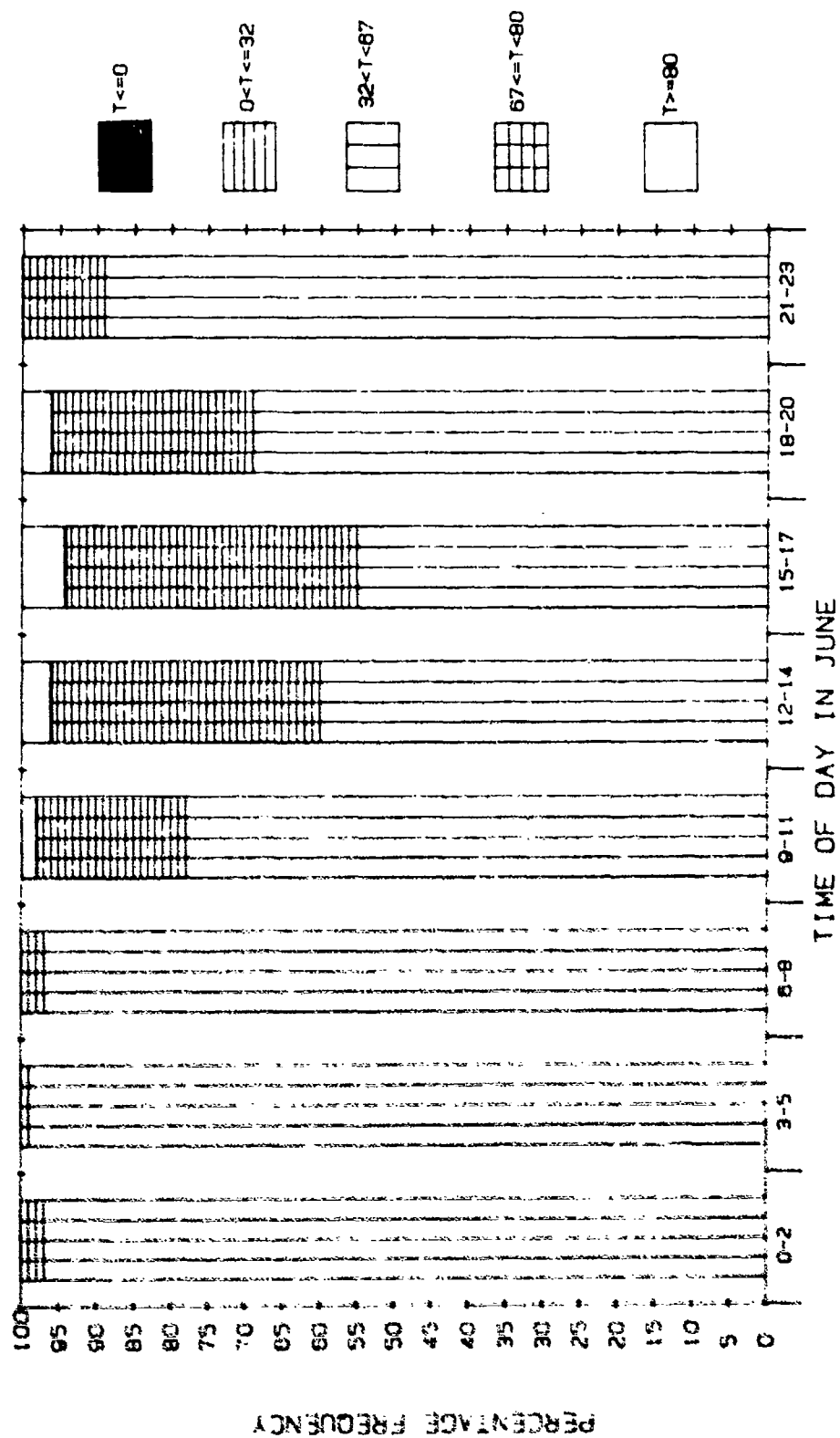


Figure A-50. Frequency of Occurrence for Temperature (T °F), Mean of German Airbases.

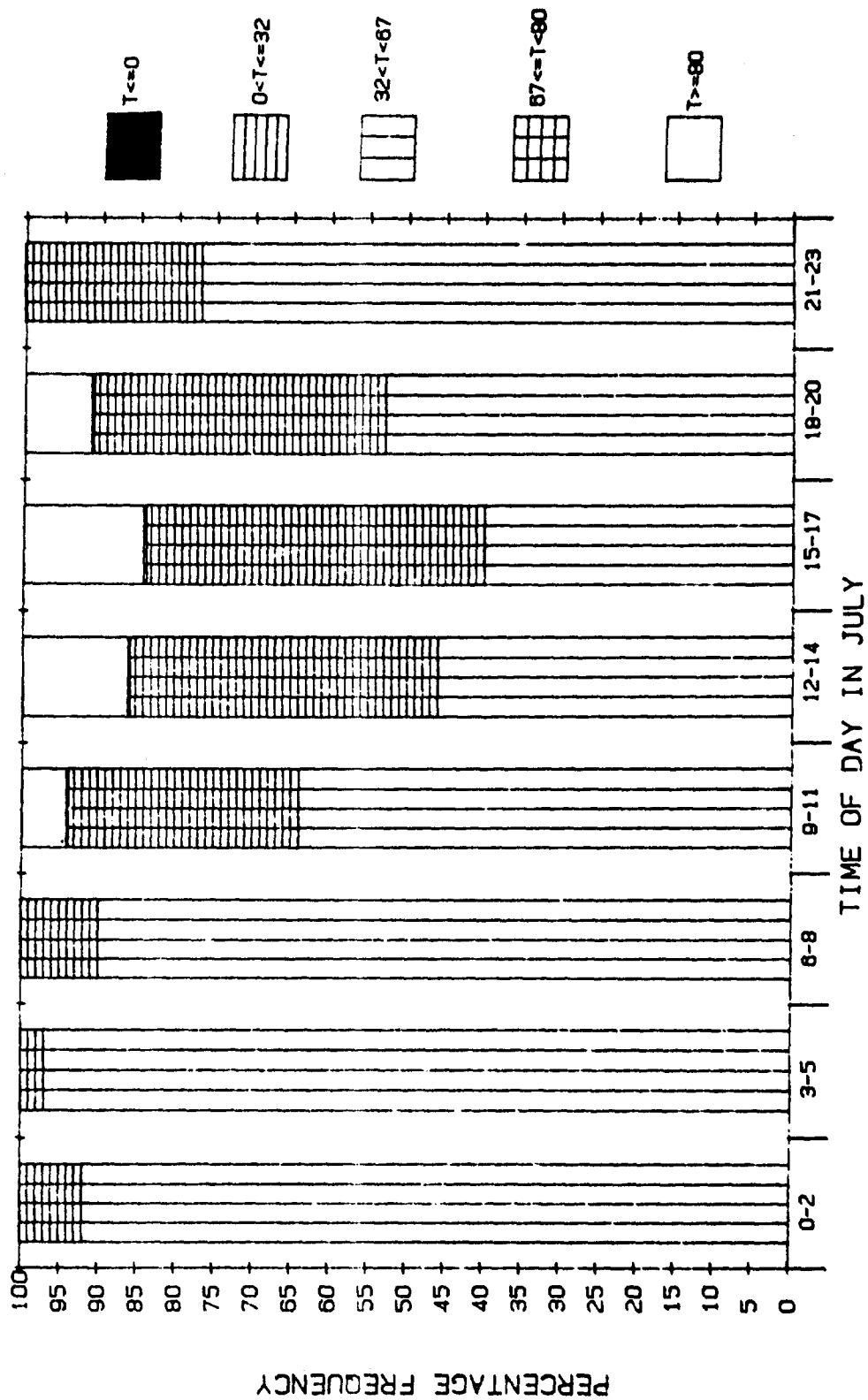


Figure A-51. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

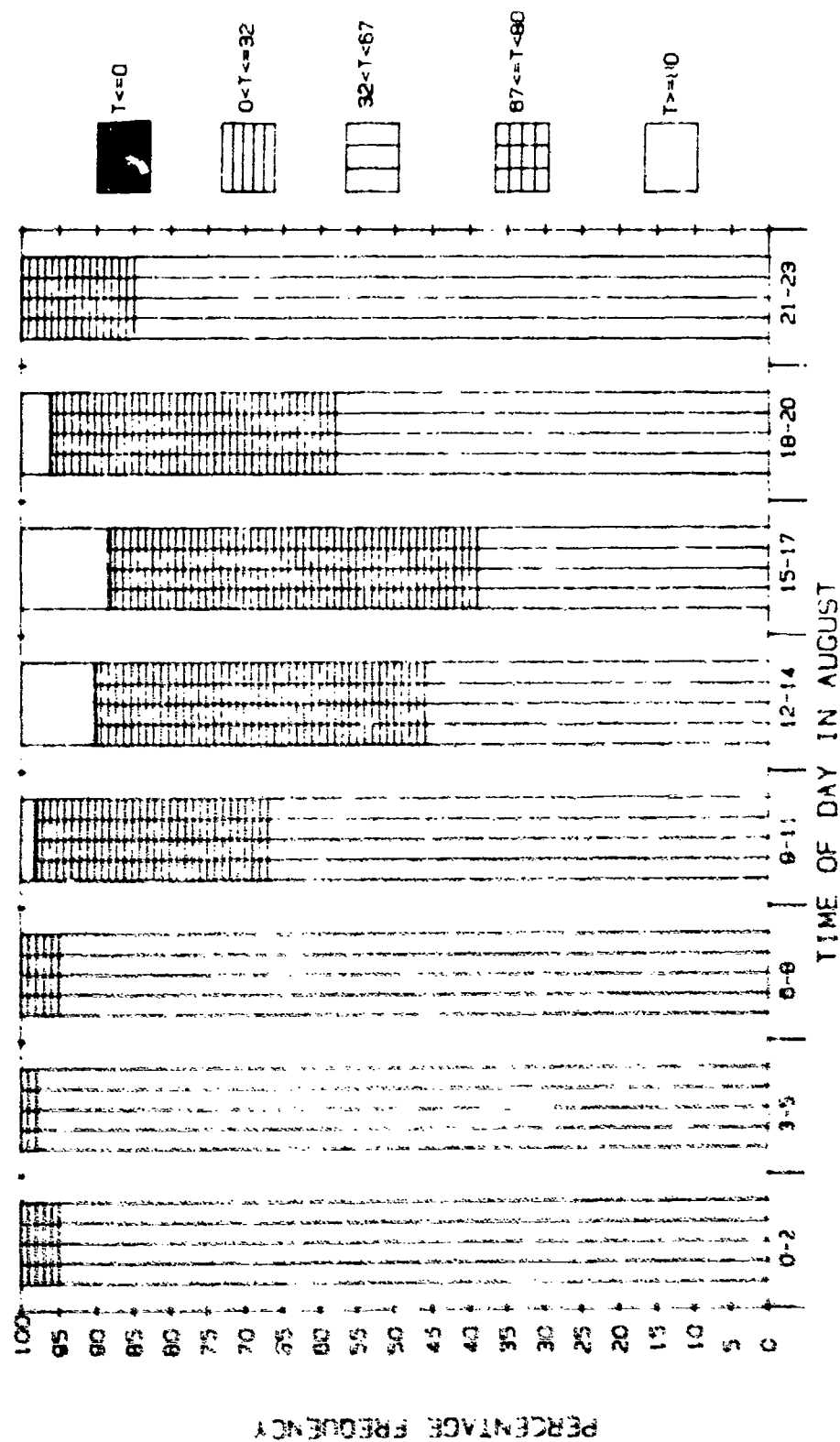


Figure A-52. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

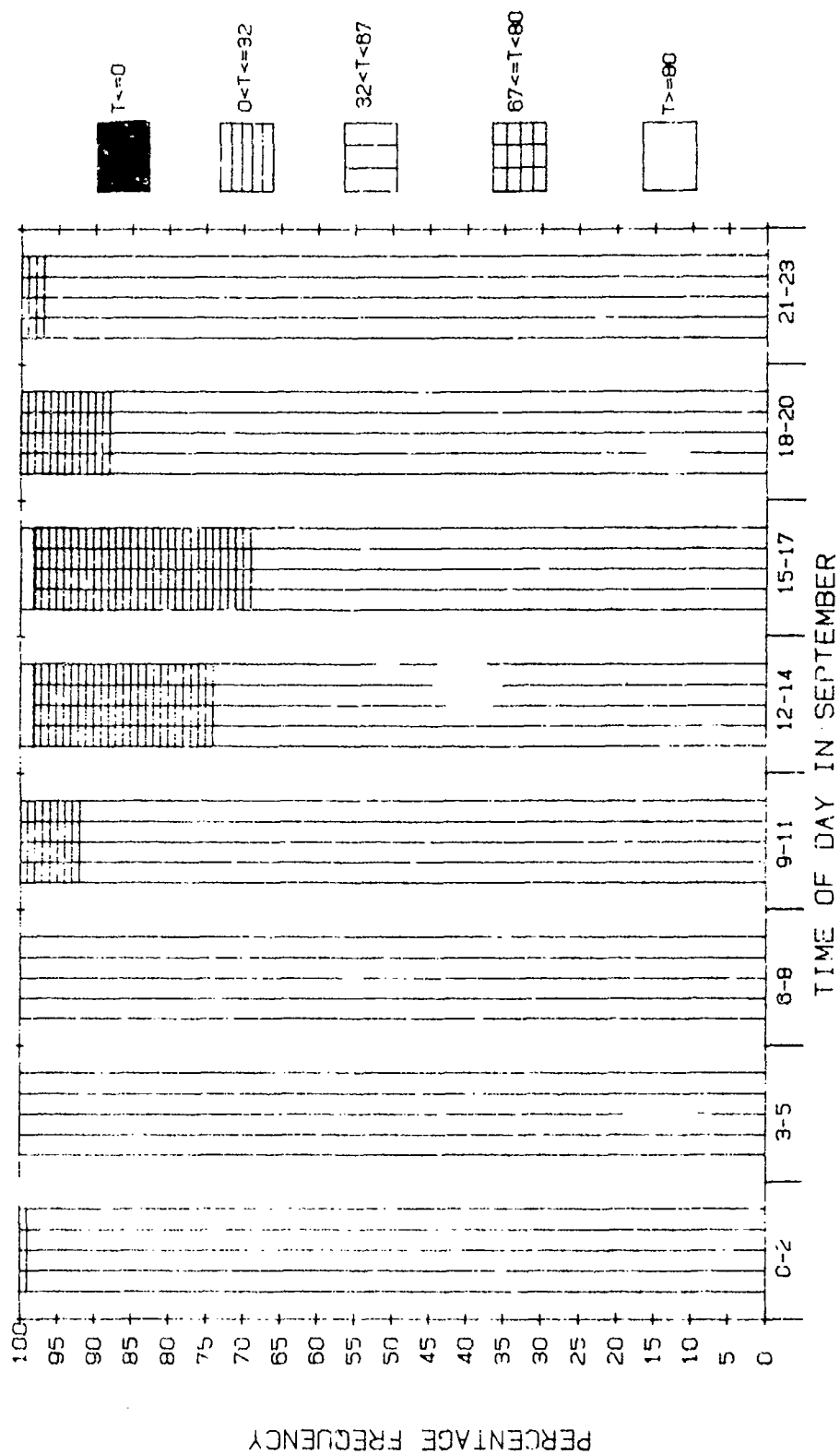


Figure A-53. Frequency of Occurrence for Temperature (T °F), Mean of German Airbases.

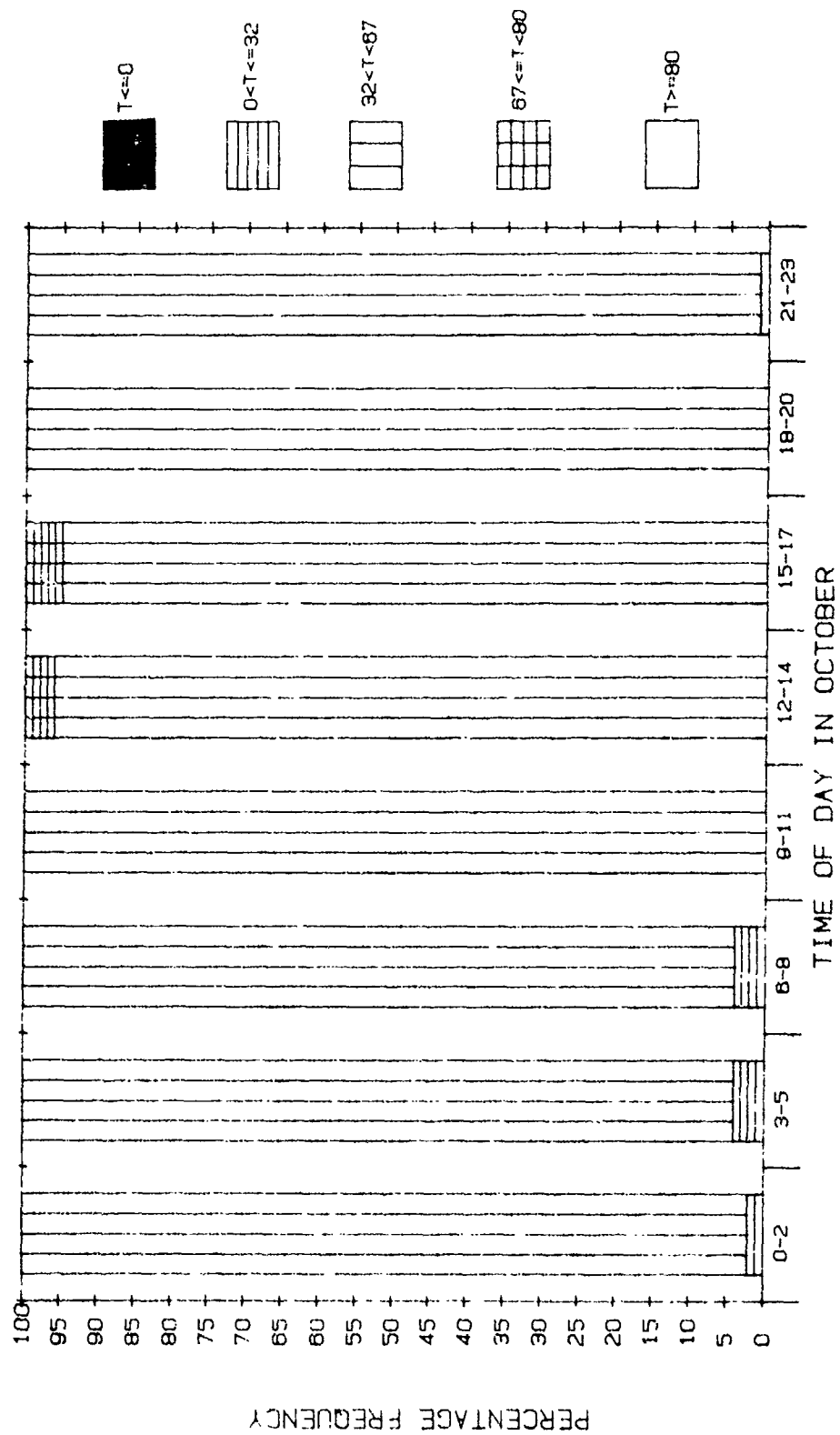


Figure A-54. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

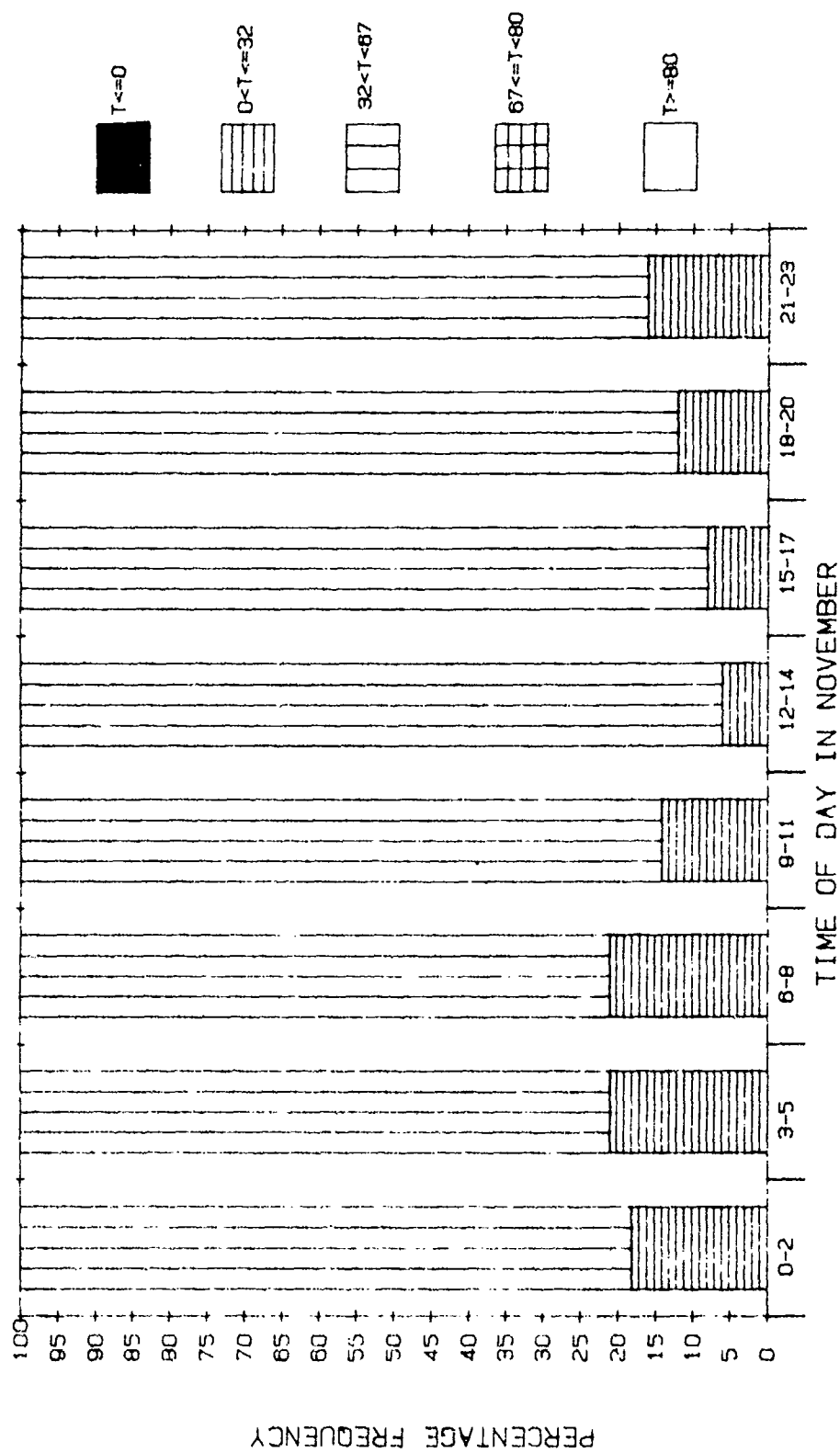


Figure A-55. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

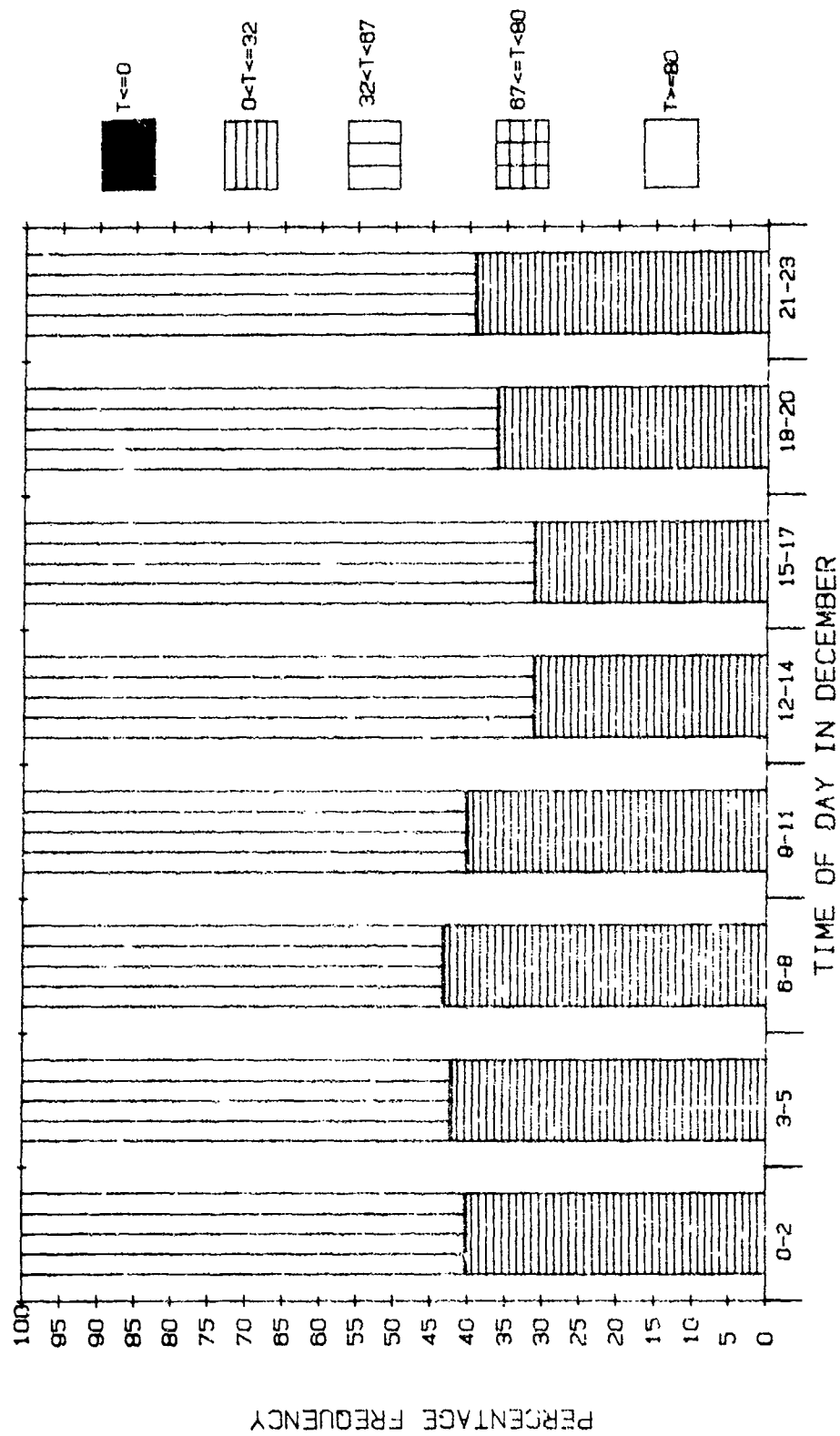


Figure A-56. Frequency of Occurrence for Temperature ($T^{\circ}\text{F}$), Mean of German Airbases.

d. Duration of Extreme Temperatures

(1) Temperature $\leq 32^{\circ}\text{F}$

(2) Temperature $\geq 80^{\circ}\text{F}, 85^{\circ}\text{F}, 90^{\circ}\text{F}$

These graphs represent unconditional durations of temperatures for at least the number of hours indicated. If the temperature was recorded to be below freezing for three consecutive hourly observations, the events recorded would be: three observations occur in subfreezing temperatures which last at least 2 hours; three observations occur in subfreezing temperatures which last at least 1 hour; and three observations occur in subfreezing temperatures which last at least "0 hours" (that is, three observations of subfreezing temperatures occur).

EXAMPLE: Consider the duration of temperature $\leq 32^{\circ}\text{F}$ in January at Upper Heyford (Figure A-57). Approximately 7 percent of the recorded observations were temperatures below freezing that lasted at least 10 hours. The conditional probability of the duration can be calculated by considering the ratio of this value to the percent of time that any subfreezing observations were made.

In the same graph, then, note that approximately 13 percent of the observations recorded temperatures less than 32°F . Thus, $7/13 = .54$ indicates that in 54 percent of the observations where temperature is recorded to be below freezing, the subfreezing temperature lasts at least 10 hours.

Similar arguments can be made concerning the graphs of extremely high temperatures.

Note that the worst-case situation was defined to be the base that recorded the longest duration of extreme temperatures.

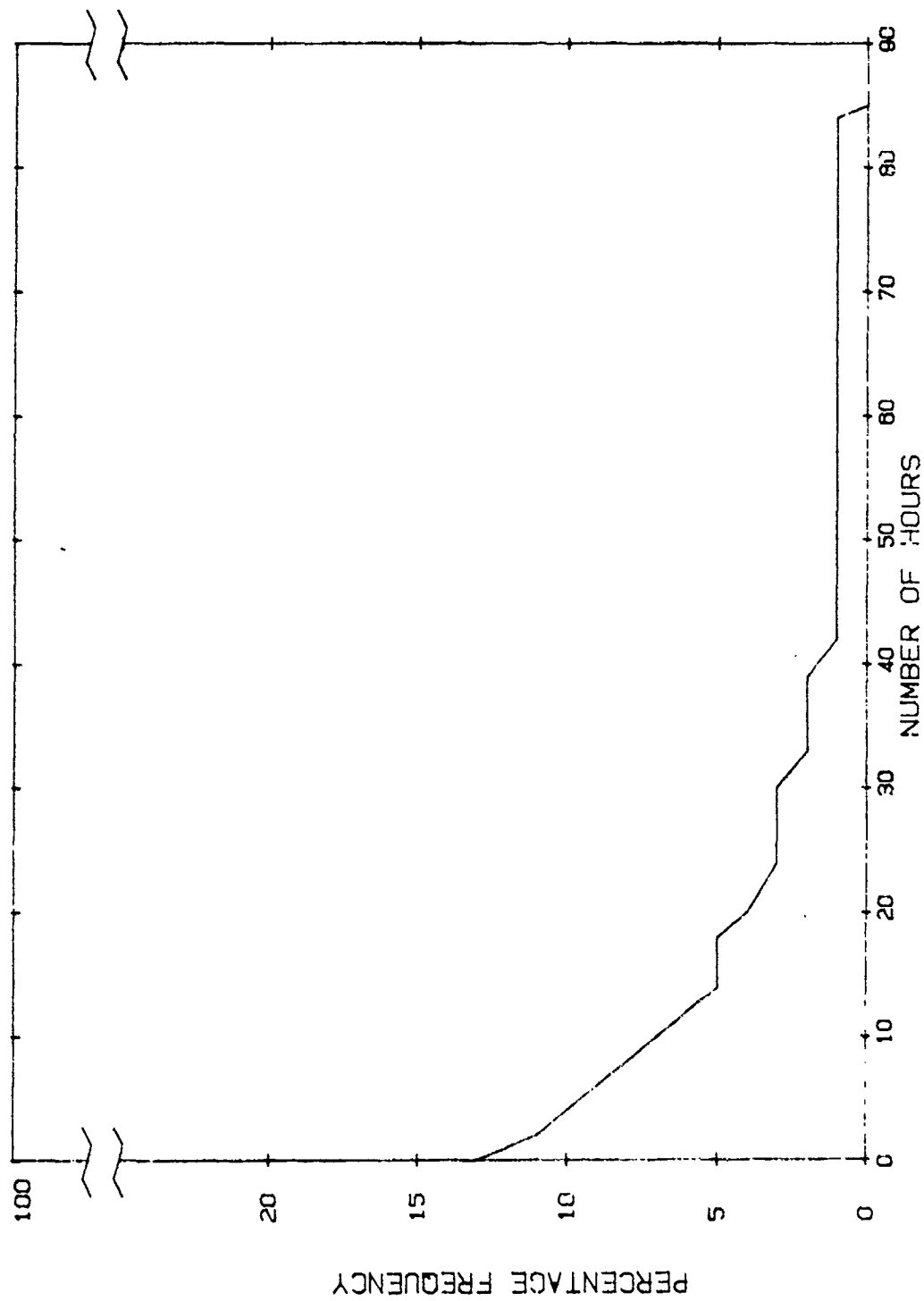


Figure A-57. Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - January.

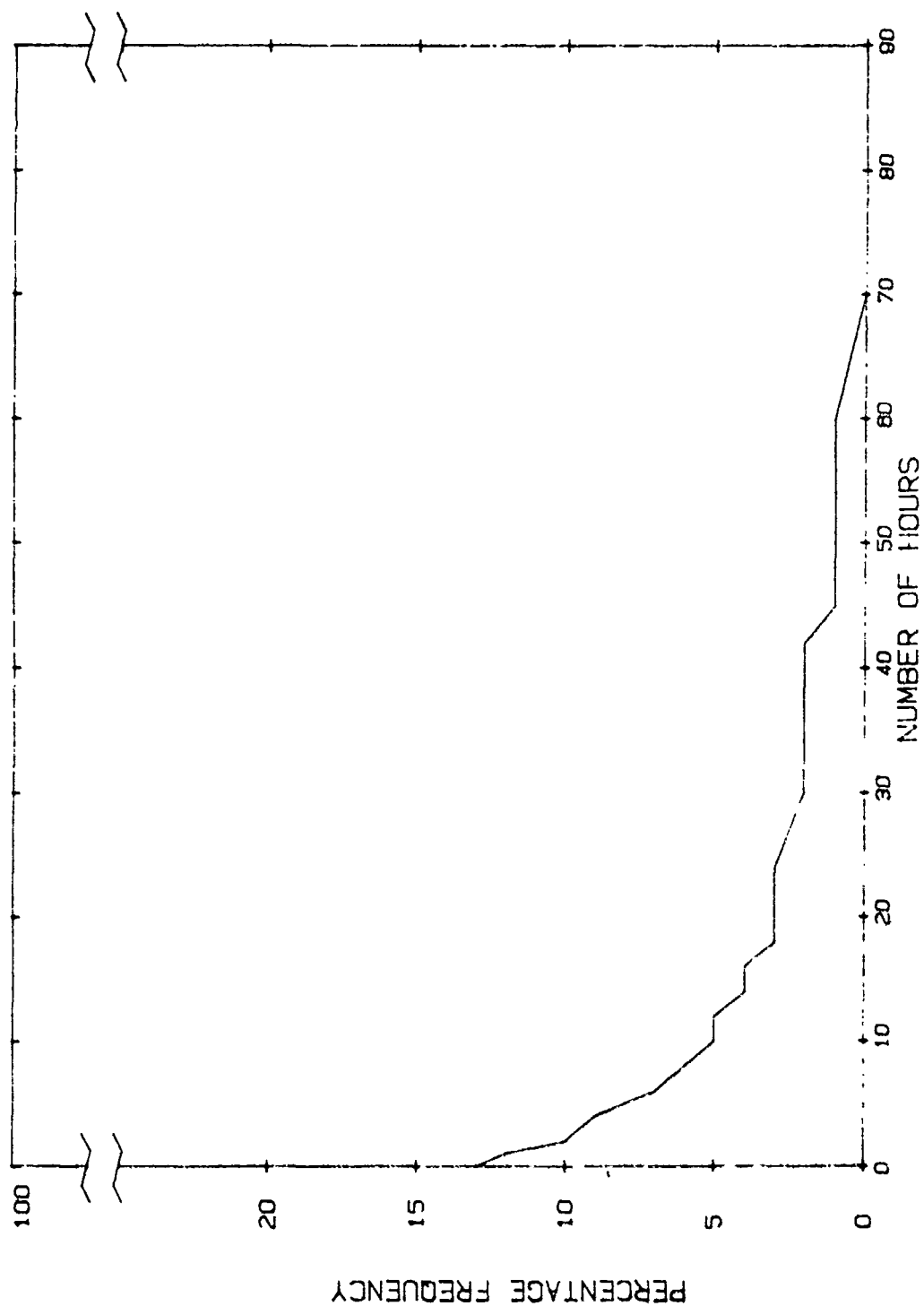


Figure A-58. Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - February.

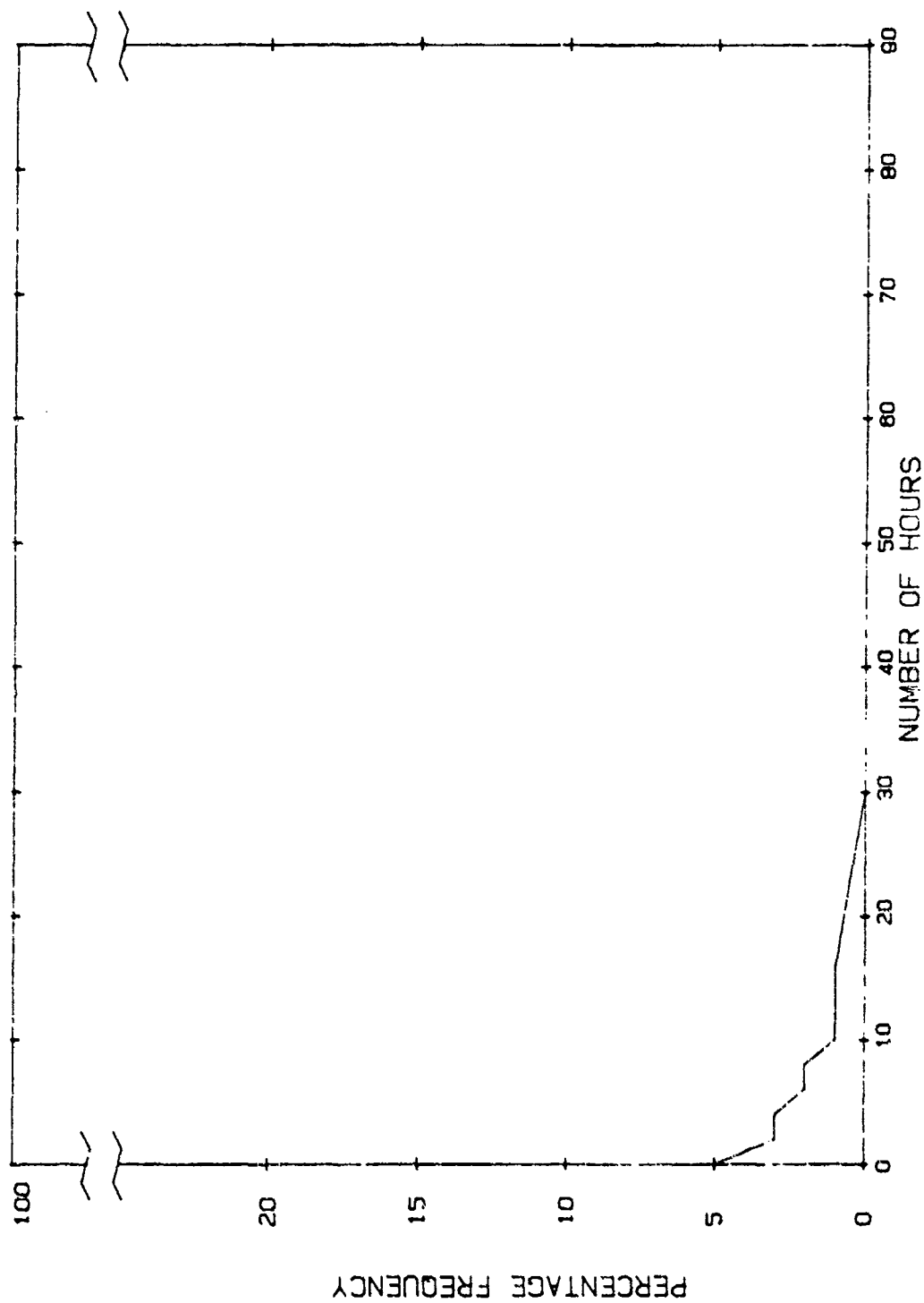


Figure A-59. Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - November.

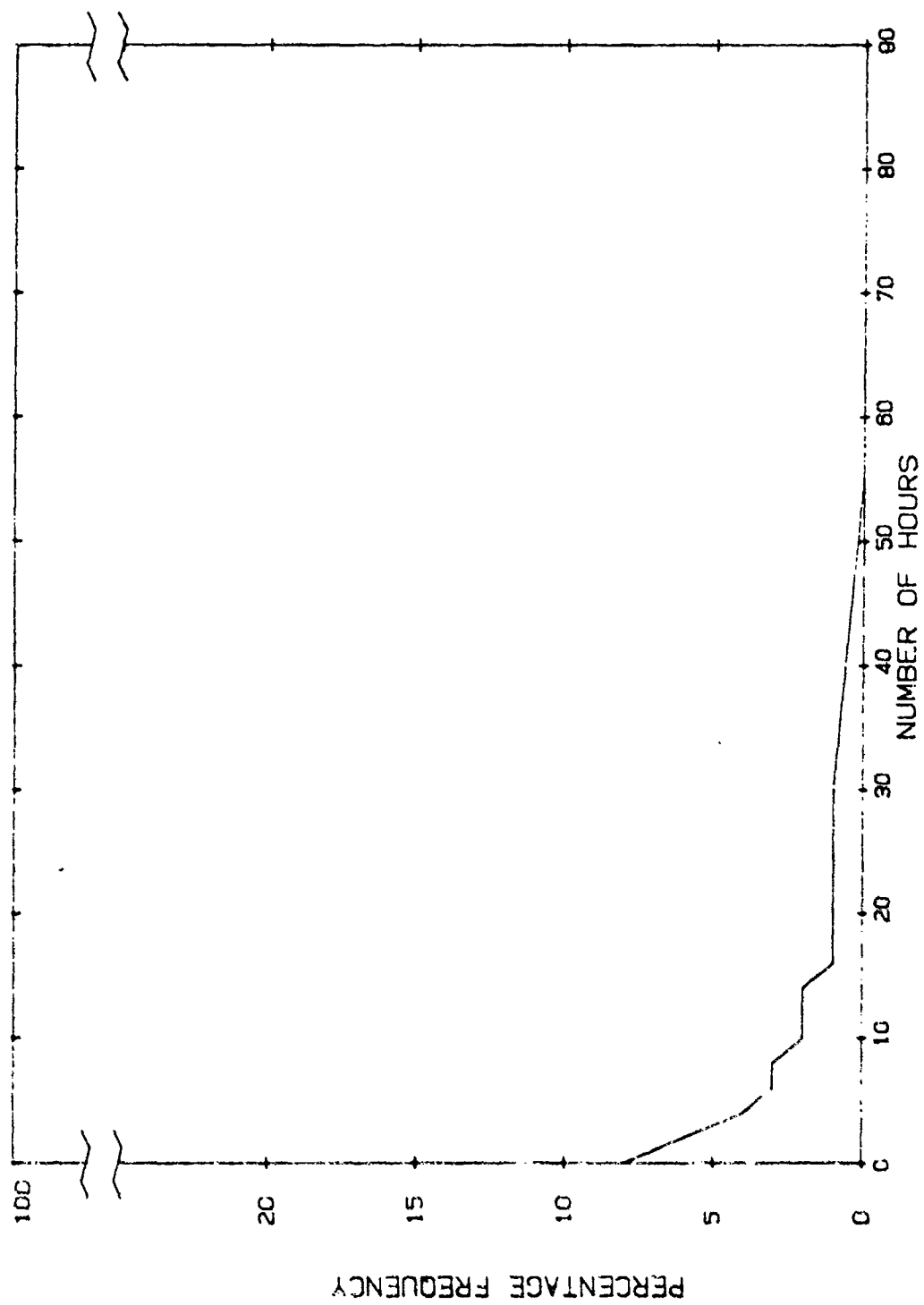


Figure A-60. Duration of Temperature $\leq 32^{\circ}\text{F}$, Upper Heyford - December.

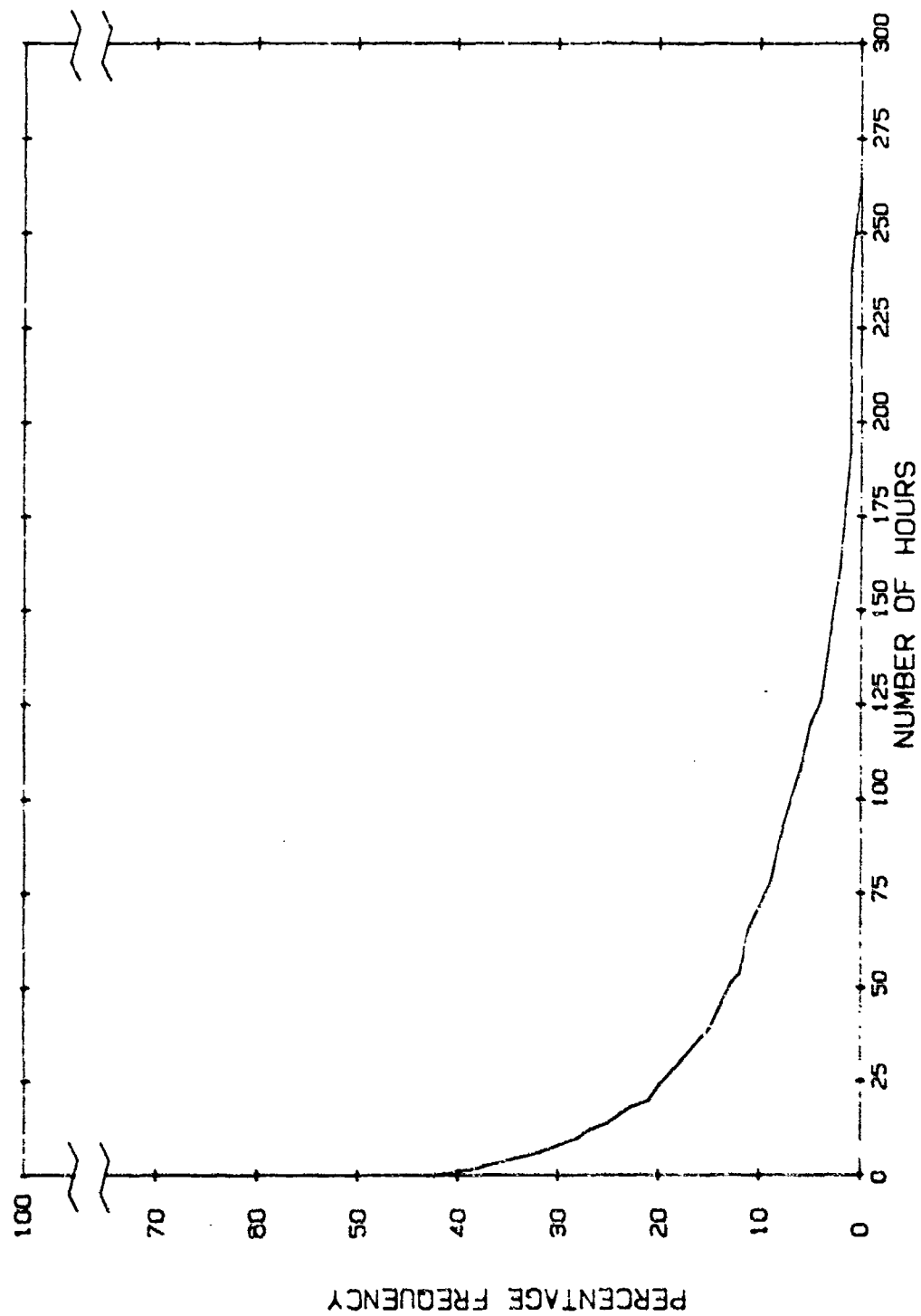


Figure A-61. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - January.

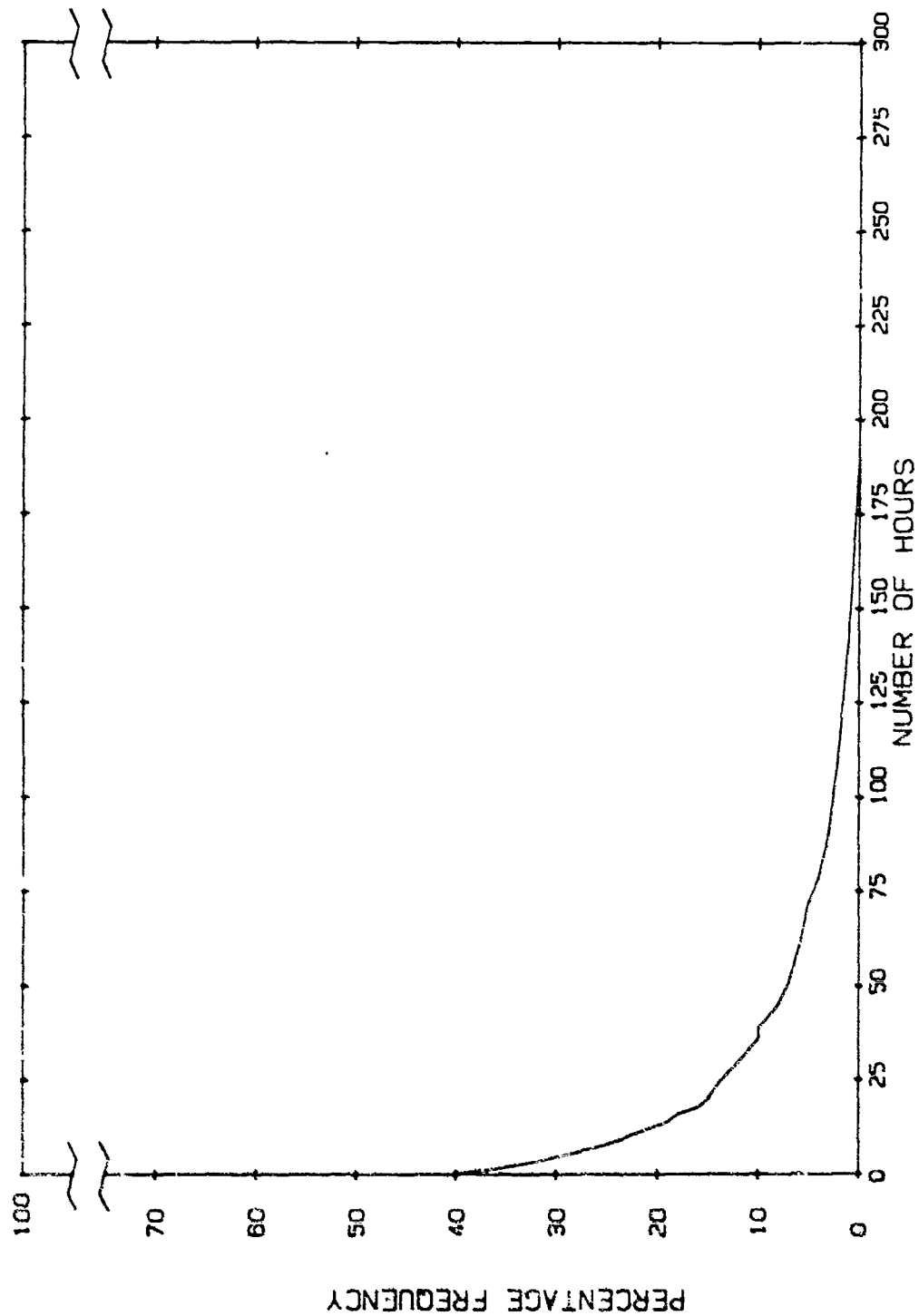


Figure A-62. Duration of Temperature $\pm 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - February.

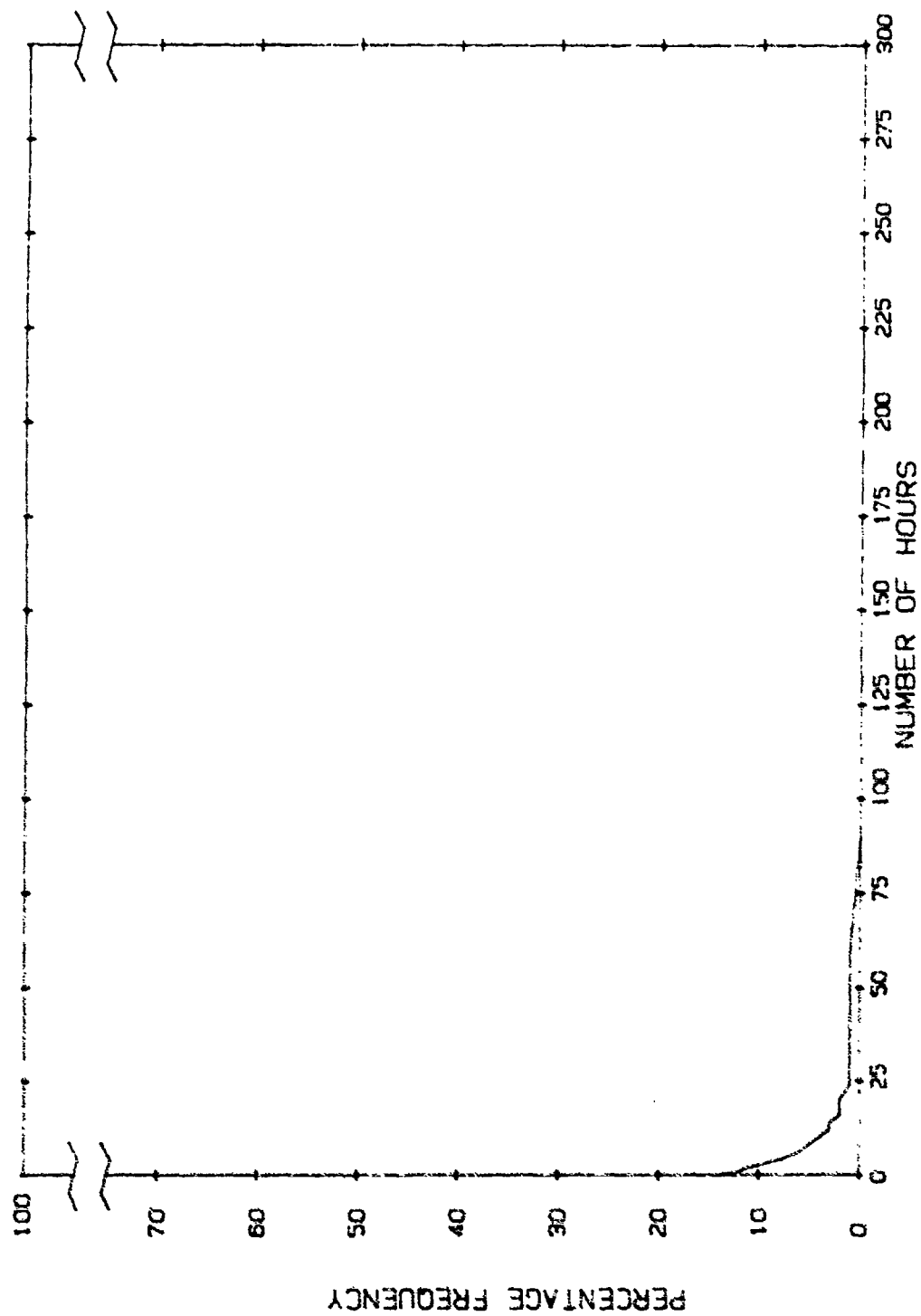


Figure A-63. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - March.

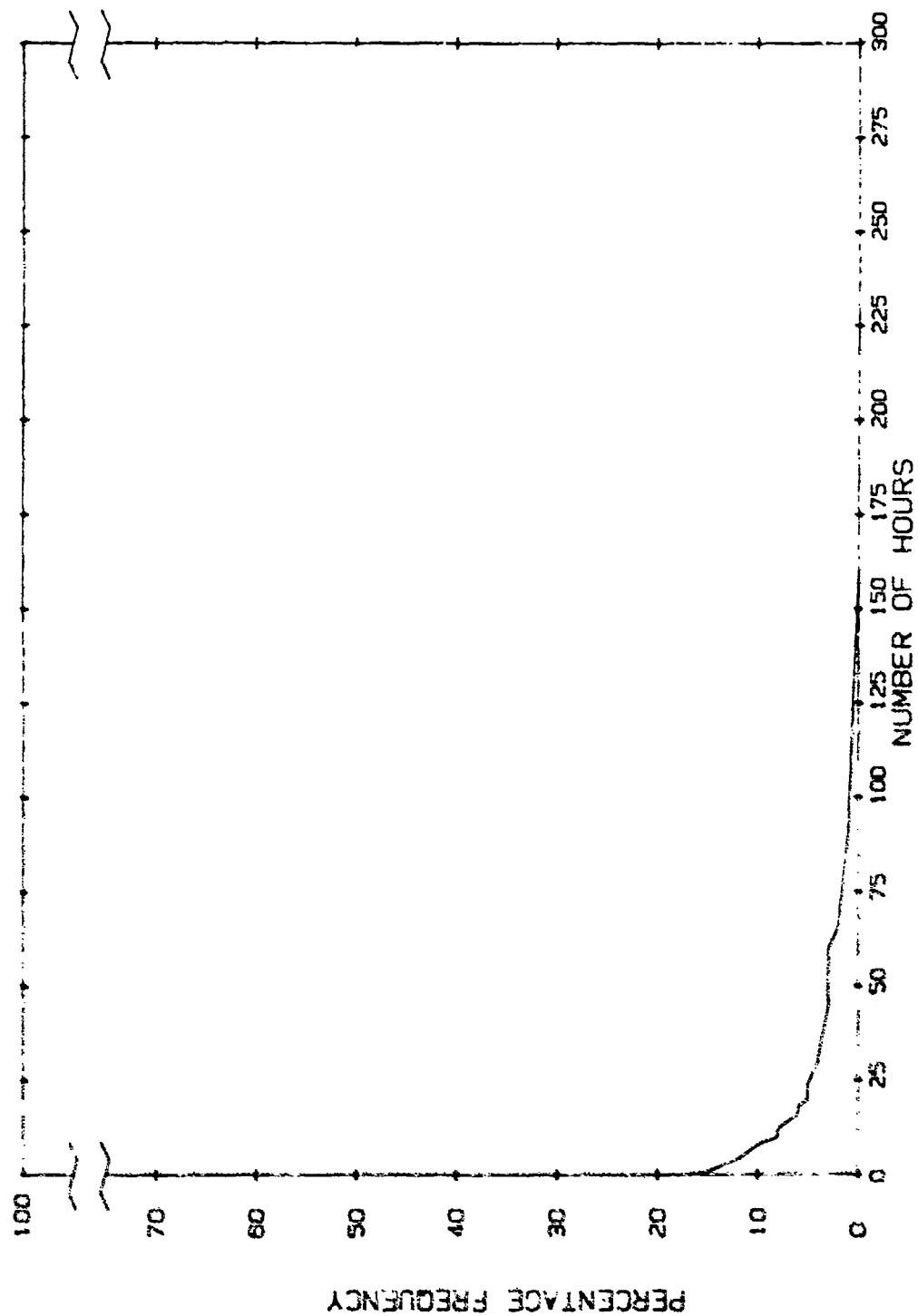


Figure A-64. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - November.

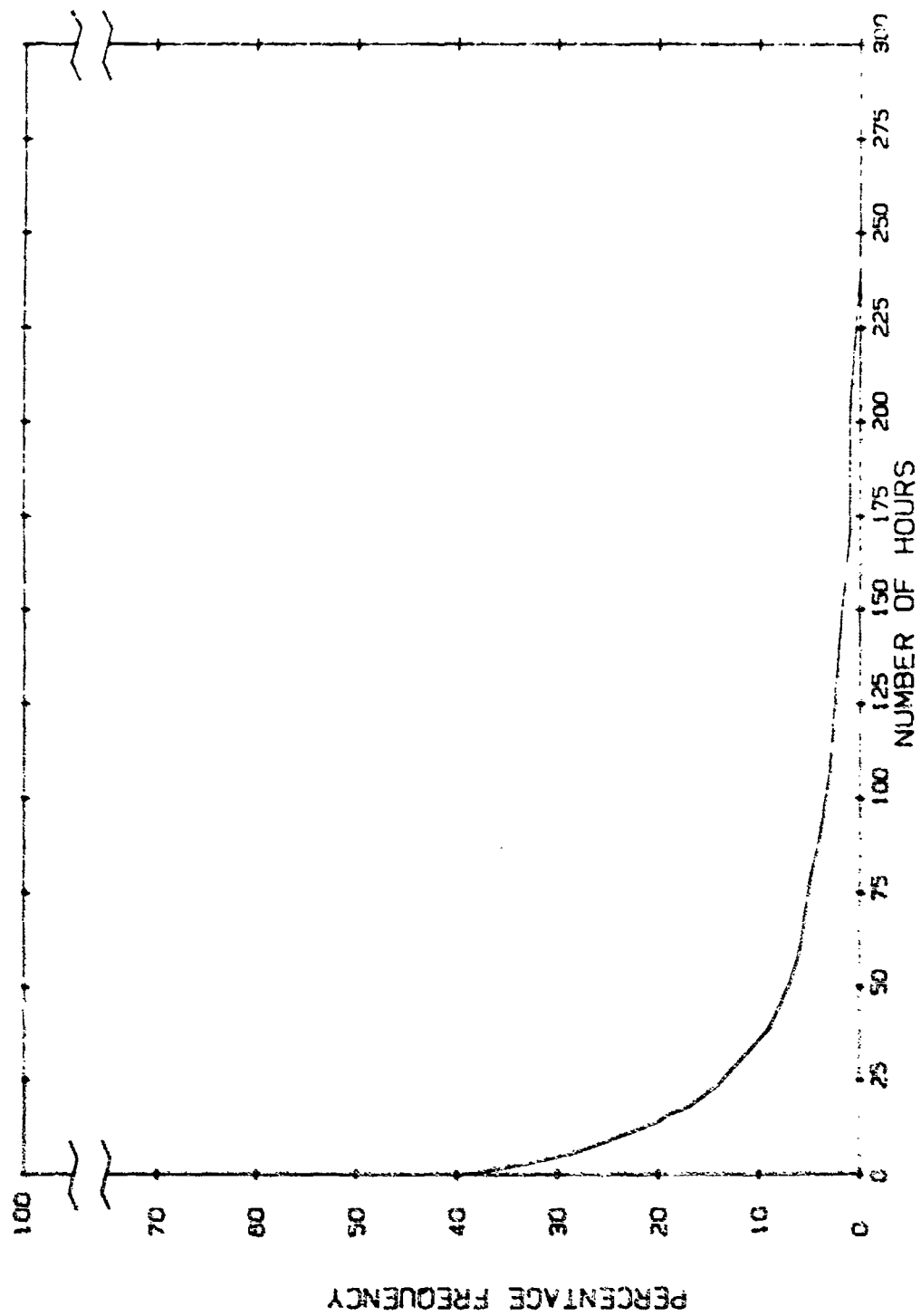


Figure A-65. Duration of Temperature $\pm 32^{\circ}\text{F}$, Worst Case in Germany: Hahn AFB - December.

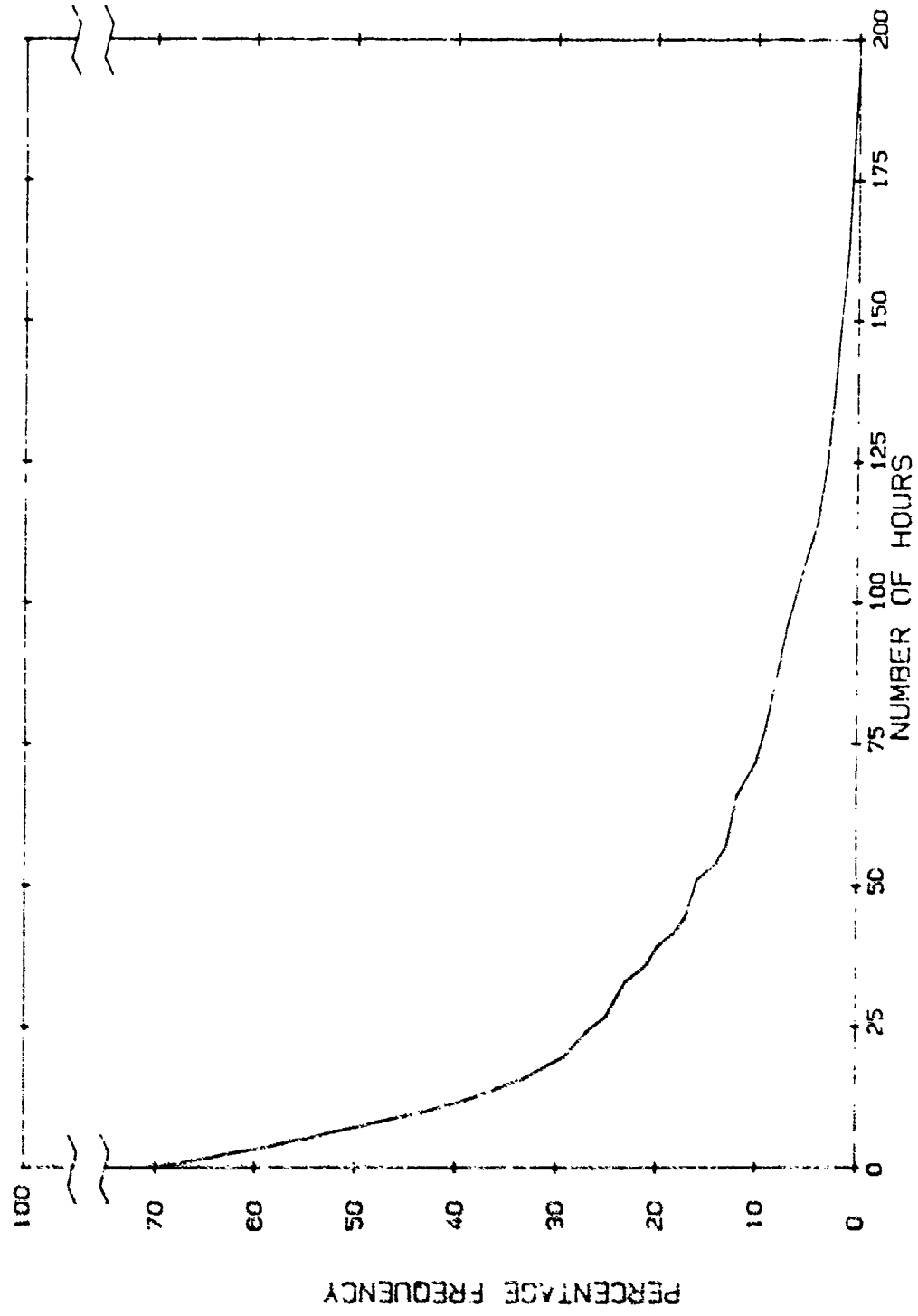


Figure A-66. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - January.

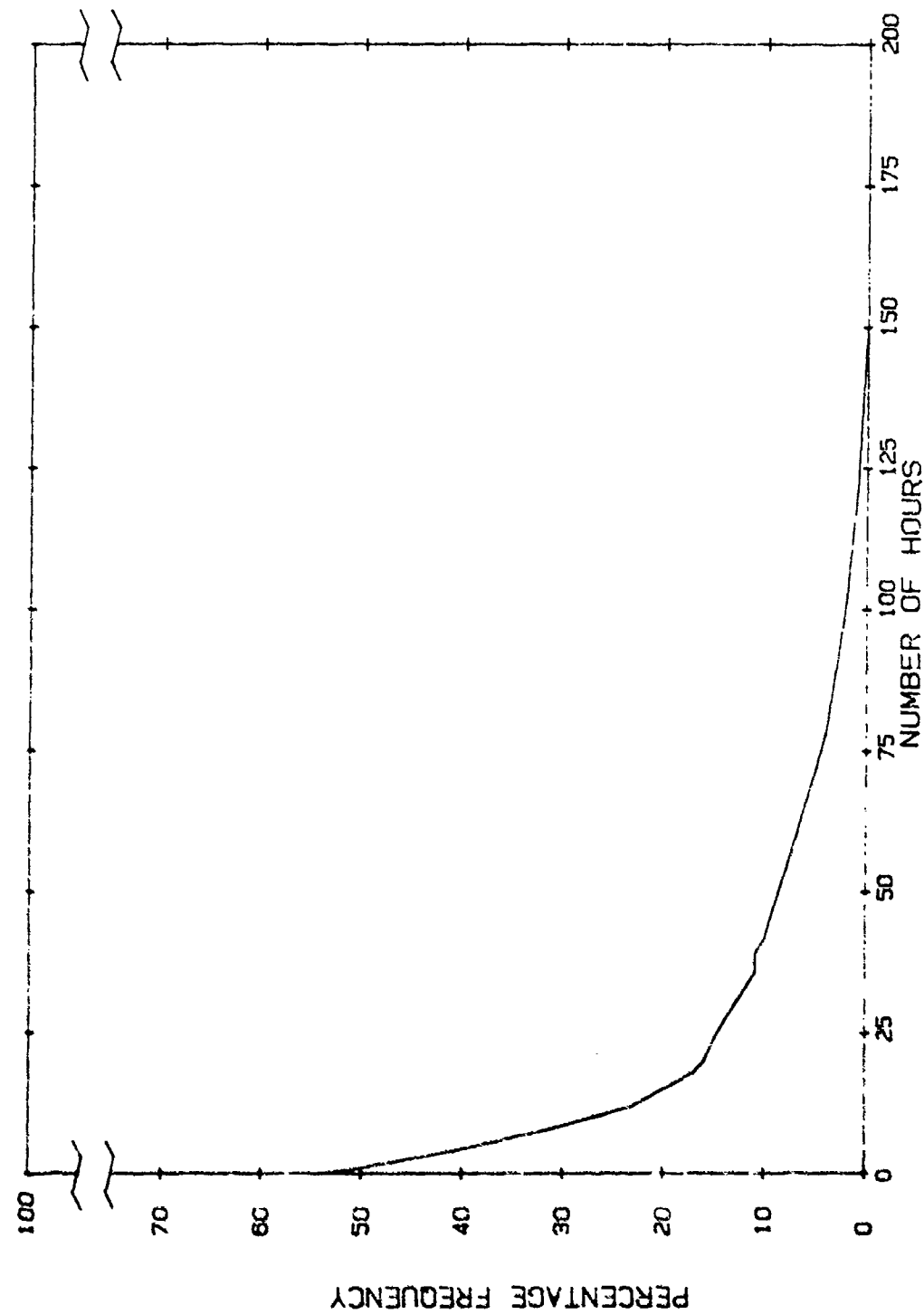


Figure A-67. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - February.

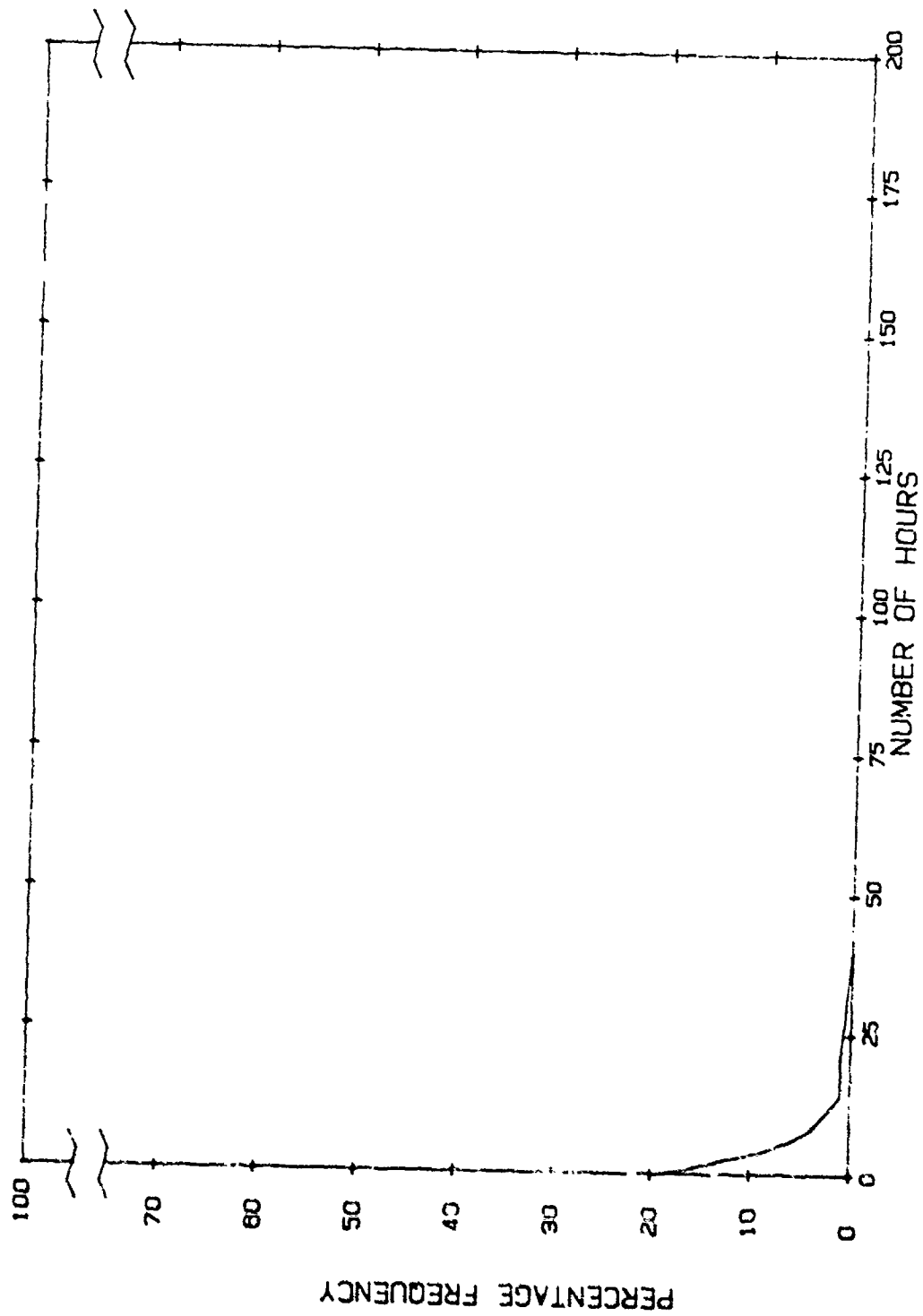


Figure A-68. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - March.

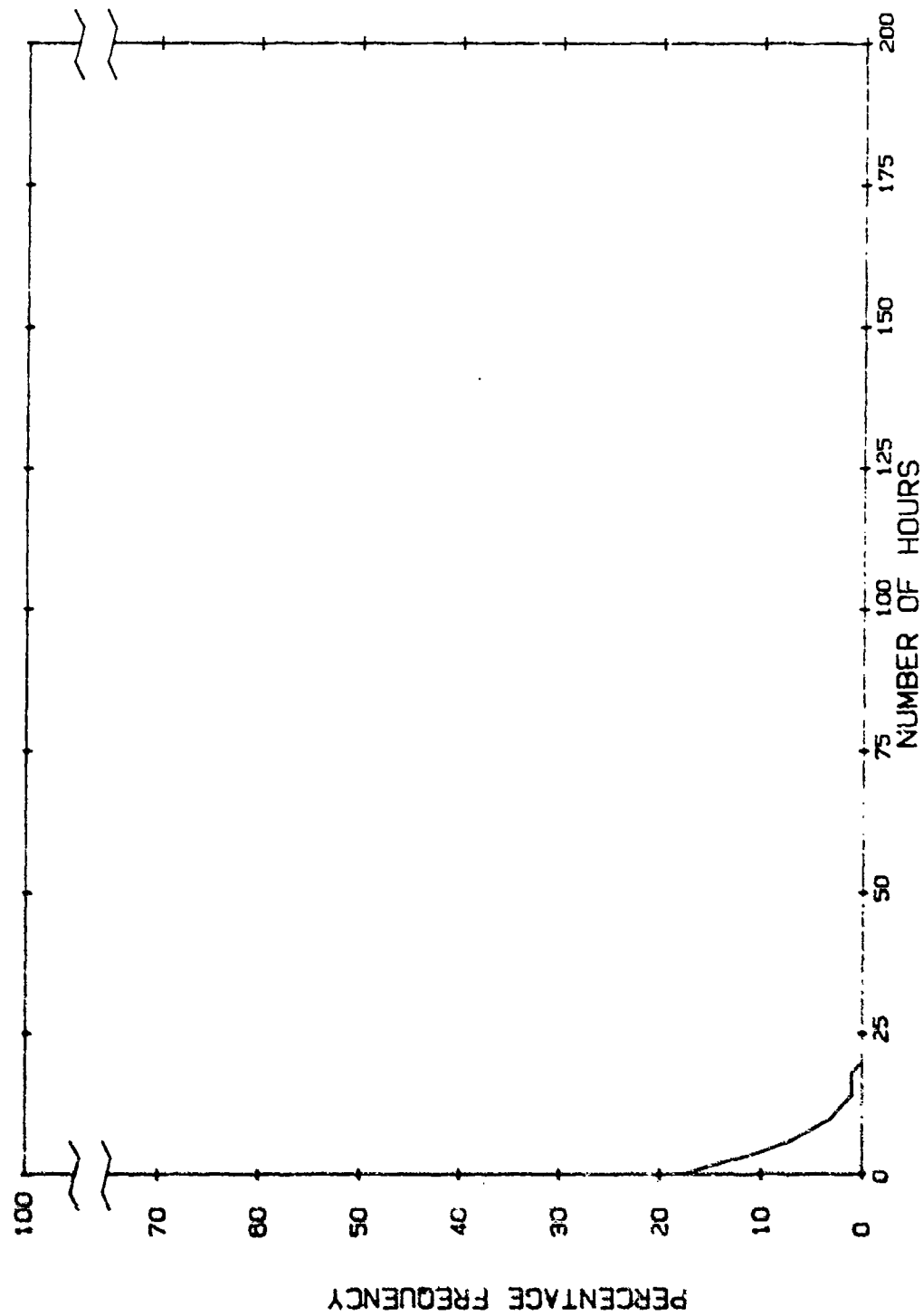


Figure A-69. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - November.

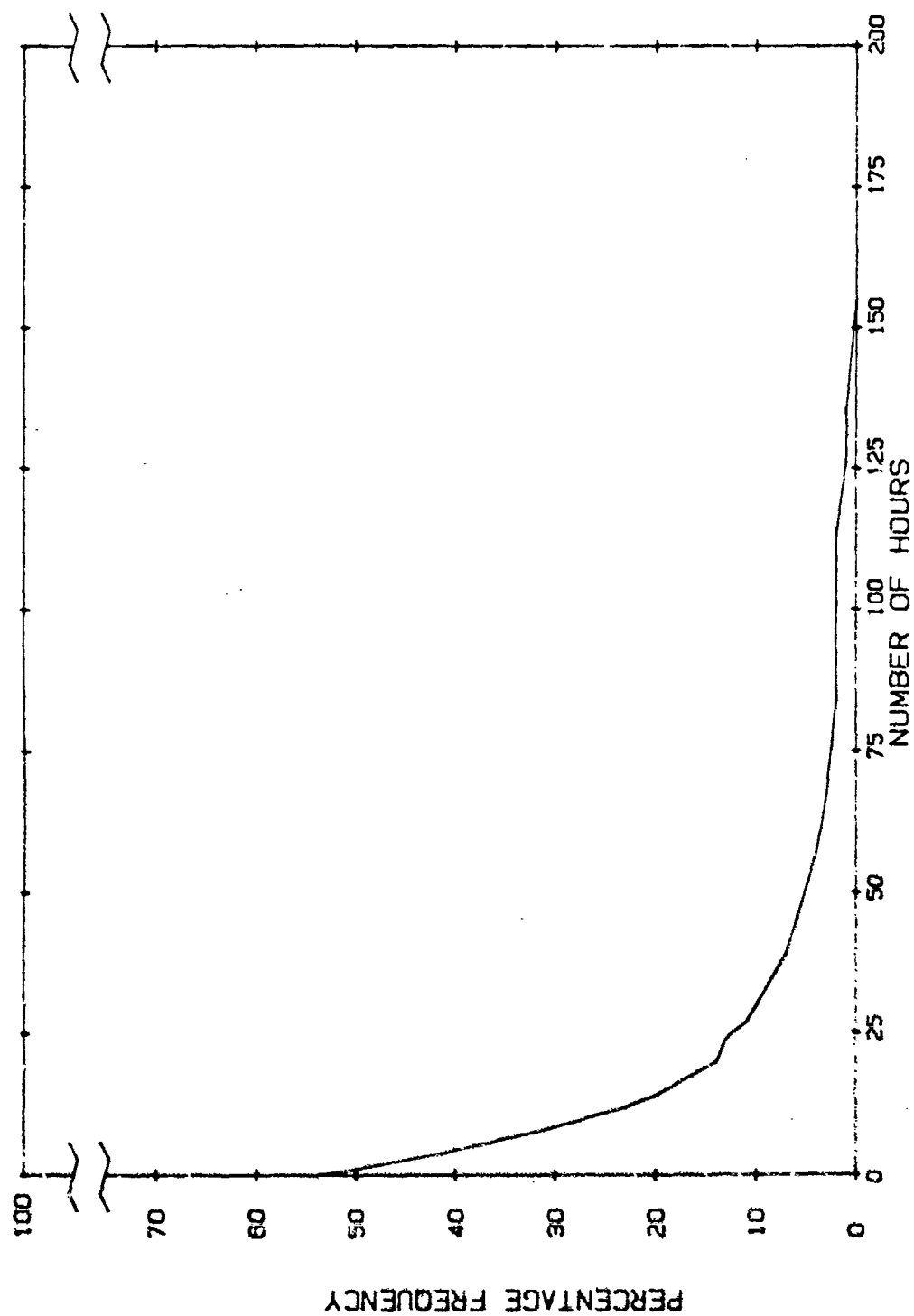


Figure A-70. Duration of Temperature $\leq 32^{\circ}\text{F}$, Worst Case in Korea: Osan AFB - December.

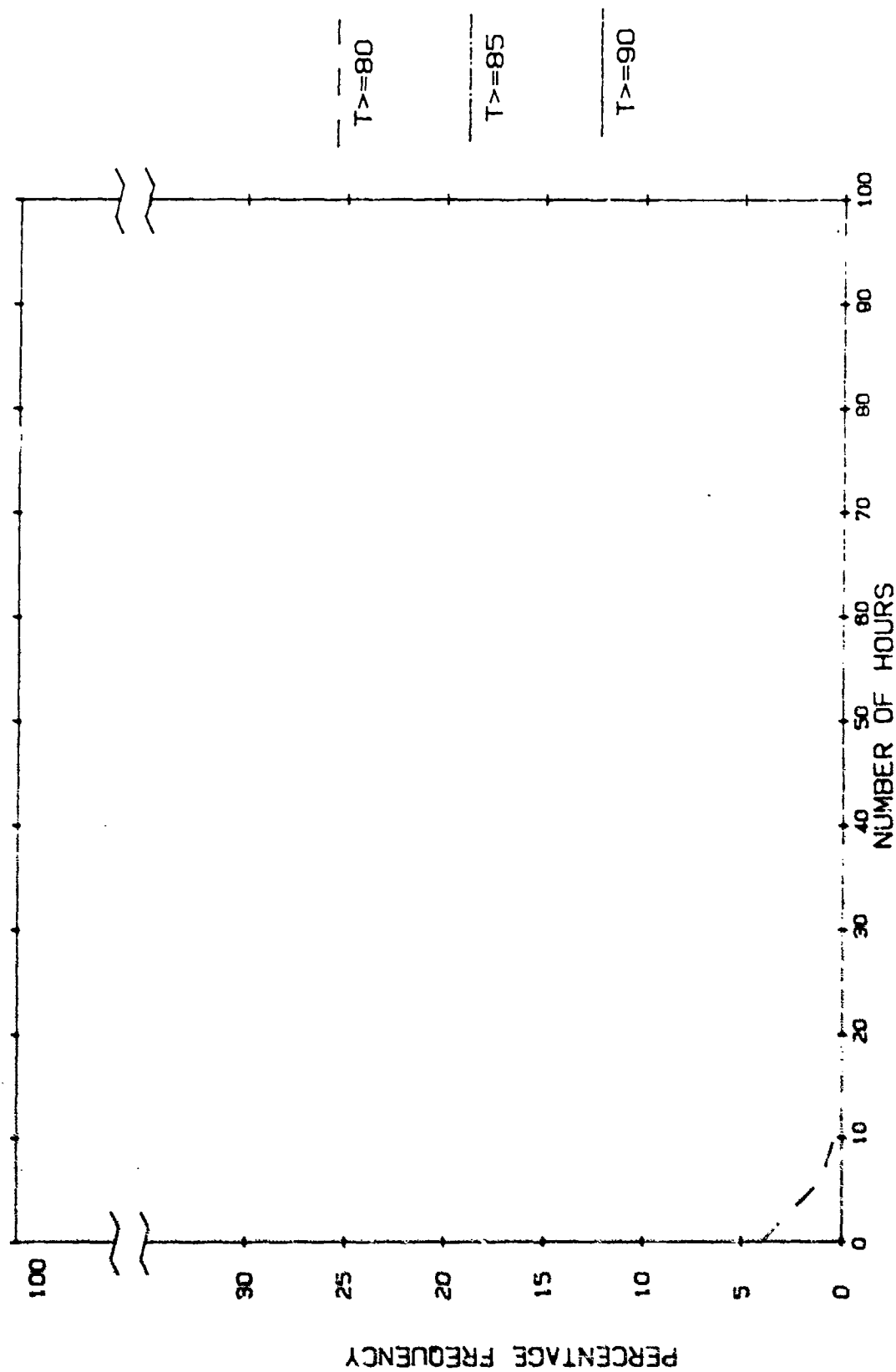


Figure A-71. Duration of Indicated Temperatures, Worst Case in Germany: Ramstein AFB - June.

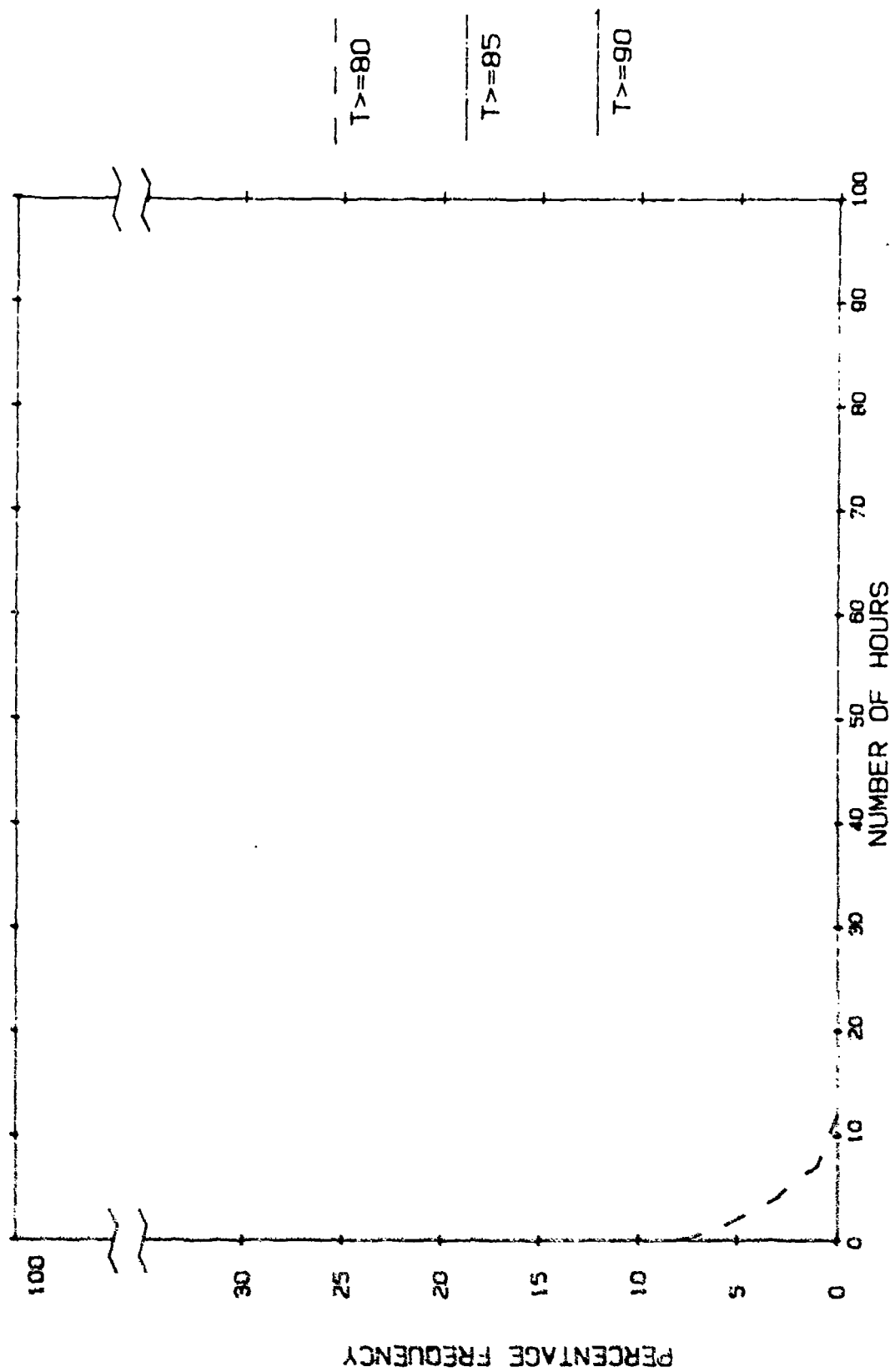


Figure A-72. Duration of Indicated Temperatures, Worst Case in Germany: Ramstein AFB - July.

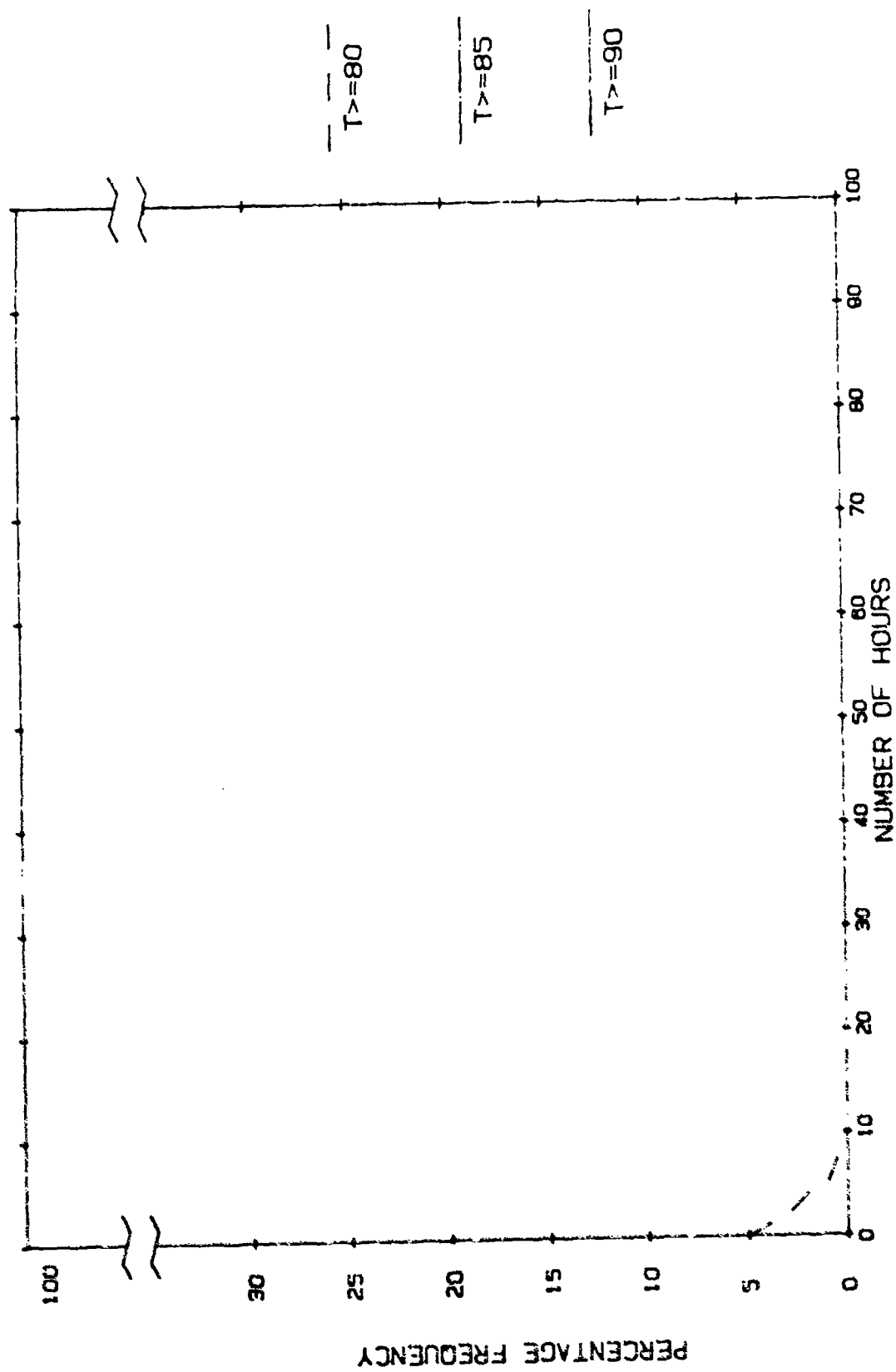


Figure A-73. Duration of Indicated Temperatures, Worst Case in Germany: Ramstein AFB - August.

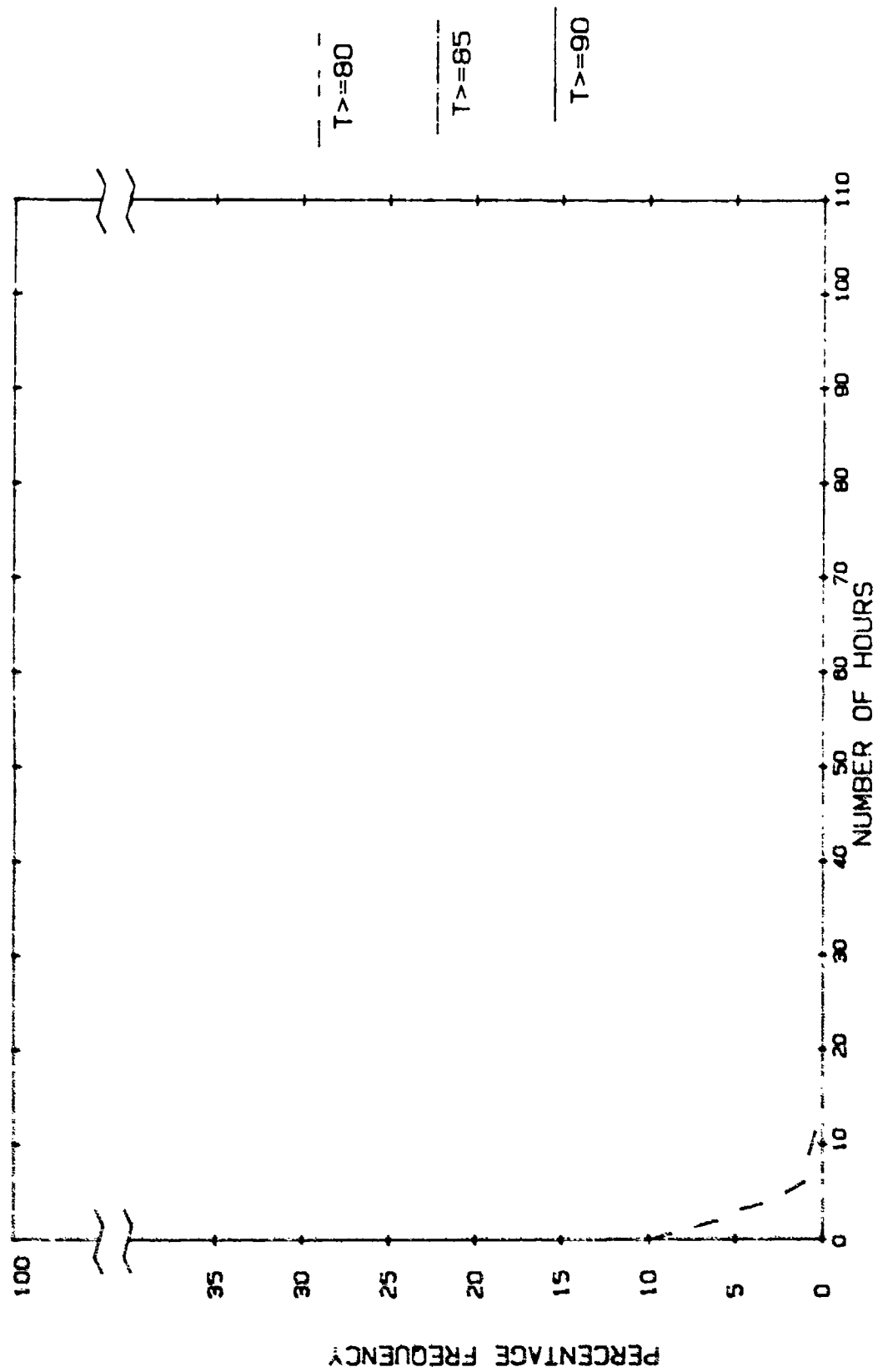


Figure A-74. Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - June.

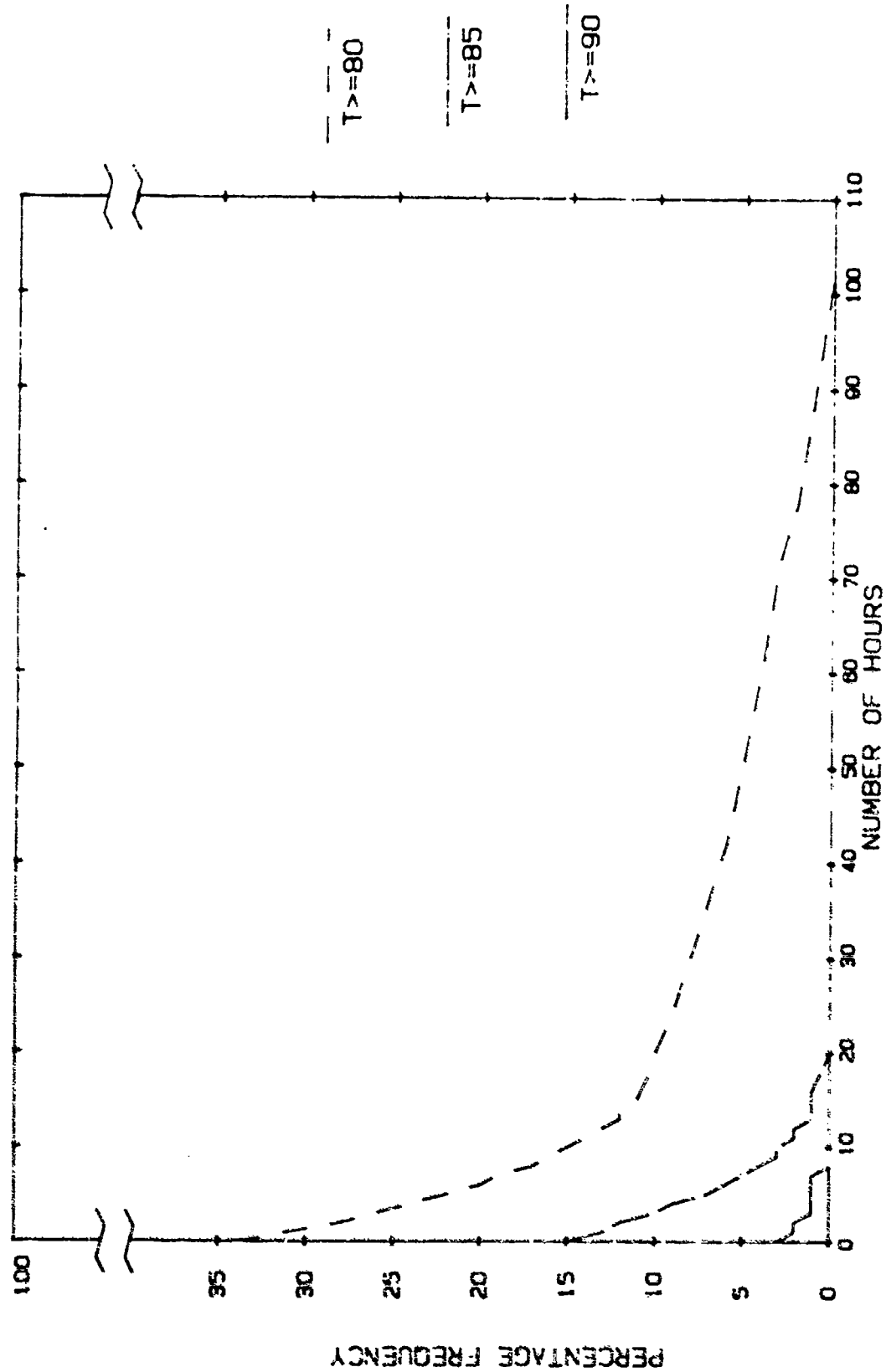


Figure A-75. Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - July.

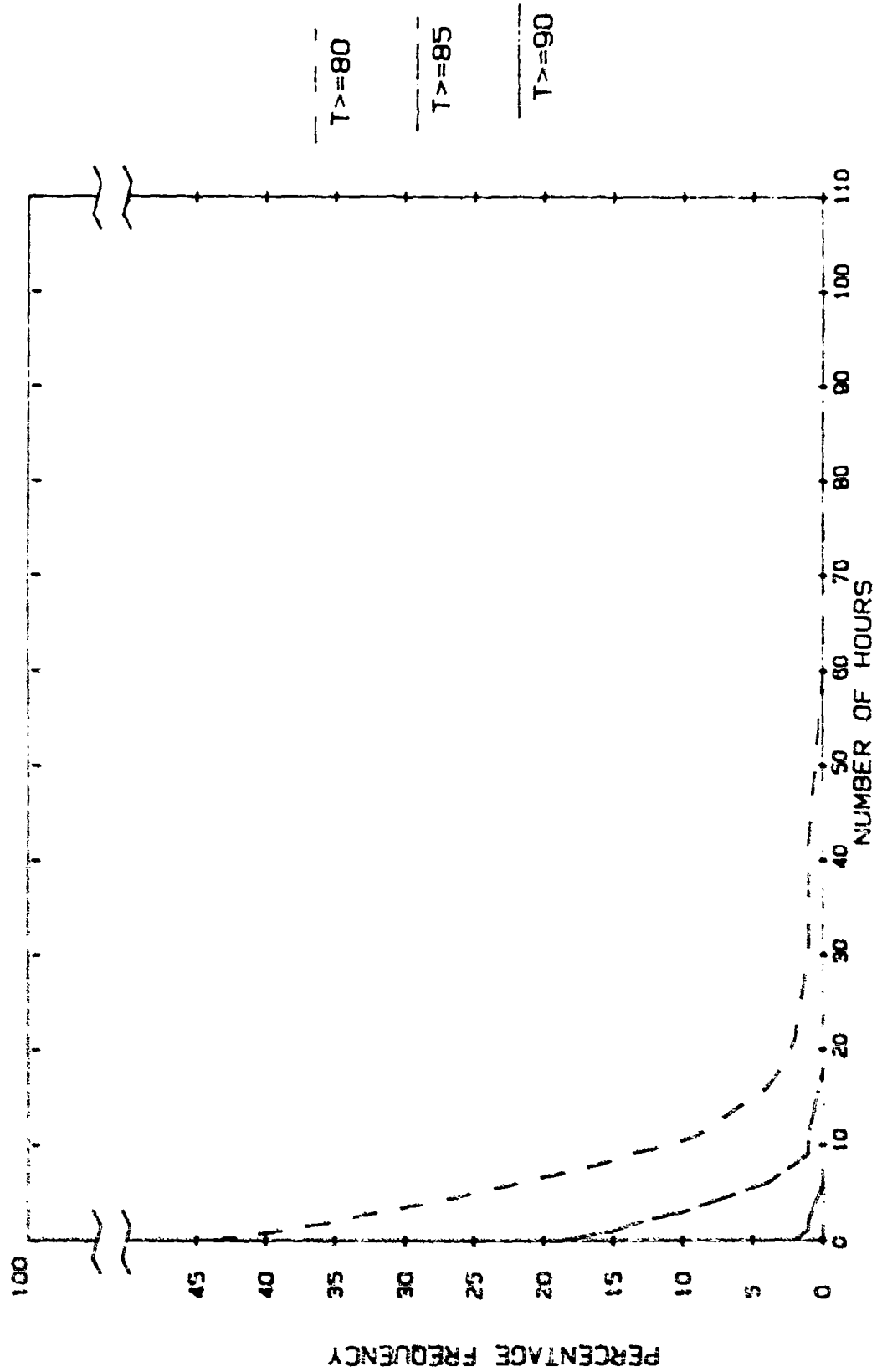


Figure A-76. Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - August.

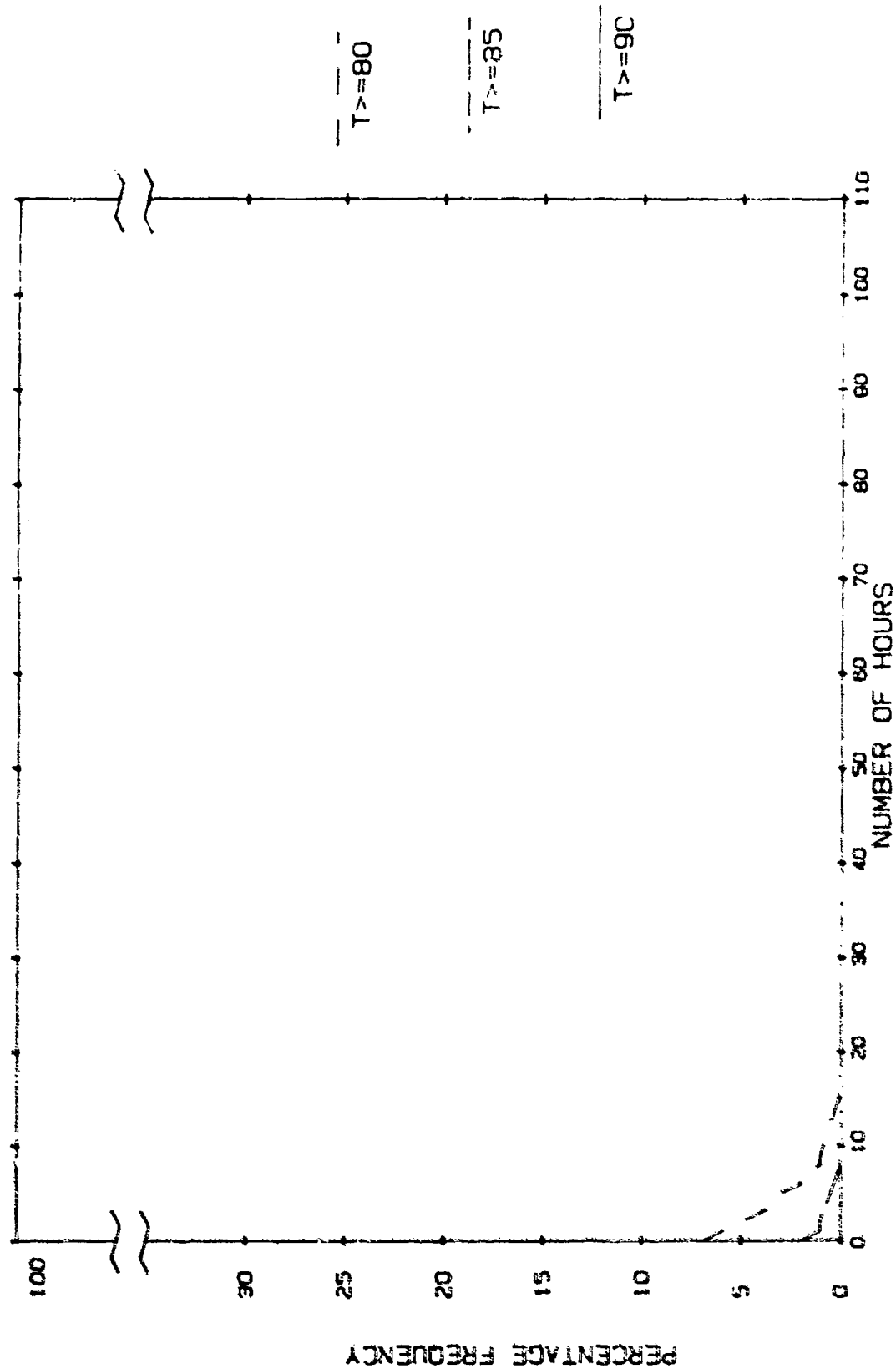


Figure A-77. Duration of Indicated Temperatures, Worst Case in Korea: Osan AFB - September.

2. PRECIPITATION

In considering precipitation, it is important to first note the following items:

(1) An observation of precipitation is recorded for the hour only if precipitation occurs at the moment of the observation.

(2) More than one form of precipitation may be recorded with the same observation.

(3) The forms of precipitation are defined below.

a. Thunderstorms - reported occurrence of thunderstorms, tornadoes and waterspouts.

b. Rain and/or drizzle - all liquid precipitation falling to the ground, but not freezing.

c. Freezing rain and/or freezing drizzle - precipitation falling in liquid form, but freezing on contact.

d. Snow and/or sleet - snow, snow pellets, sleet, ice crystals.

a. Estimates for 2-Year 1-Hour Rainfall

These rainfall intensity estimates were determined by a method described in Reference 1. A 1-hour rainfall indicates the rainfall lasts for an hour; a 2-year rainfall is one which has an annual probability of occurrence of $1/2 = .5$.

EXAMPLE: In Upper Heyford, a rainfall that potentially occurs once every other year has an estimated intensity of .32 inches/hour (Table A-1).

TABLE A-1. ESTIMATES FOR 2-YEAR 1-HOUR RAINFALL

UPPER HEYFORD	.32"/HR
BITBURG	.50"/HR
HAHN	.51"/HR
RAMSTEIN	.45"/HR
RHEIN-MAIN	.58"/HR
SEMBACH	.69"/HR
SPANGDAHLEM	.68"/HR
ZWEIBRUCKEN	.70"/HR
KUNSAN	1.8"/HR
OSAN	2.2"/HR

b. Maximum Amounts of Daily Precipitation/Snowfall/Snowdepth

For each airbase in a theater, precipitation was measured at hourly intervals. These data were combined into 24-hour groups and daily maximum amounts of precipitation were determined. The mean maximum precipitation was computed by averaging these values across each theater. Next, the largest of the maximum precipitation observations for each airbase was determined. These values were averaged across each theater to calculate the absolute maximum precipitation. The greatest of these values was labeled as worst-case precipitation of the theater.

For each year in the period of record, monthly mean maximum precipitation values were averaged. Each of these yearly means were then averaged to produce an annual mean maximum precipitation for each airbase. The annual mean maximum for the theater was found by averaging the values for each airbase in the theater.

Similar arguments can be made for snowfall and snowdepth.

EXAMPLE: Consider Upper Heyford in May (Figure A-78). The graph indicates that the average maximum amount of daily precipitation is approximately .6 inches, whereas the absolute maximum value recorded in May is 2.2 inches. Also note that the annual mean maximum amount of precipitation, 1.2 inches, is indicated to the right of the chart.

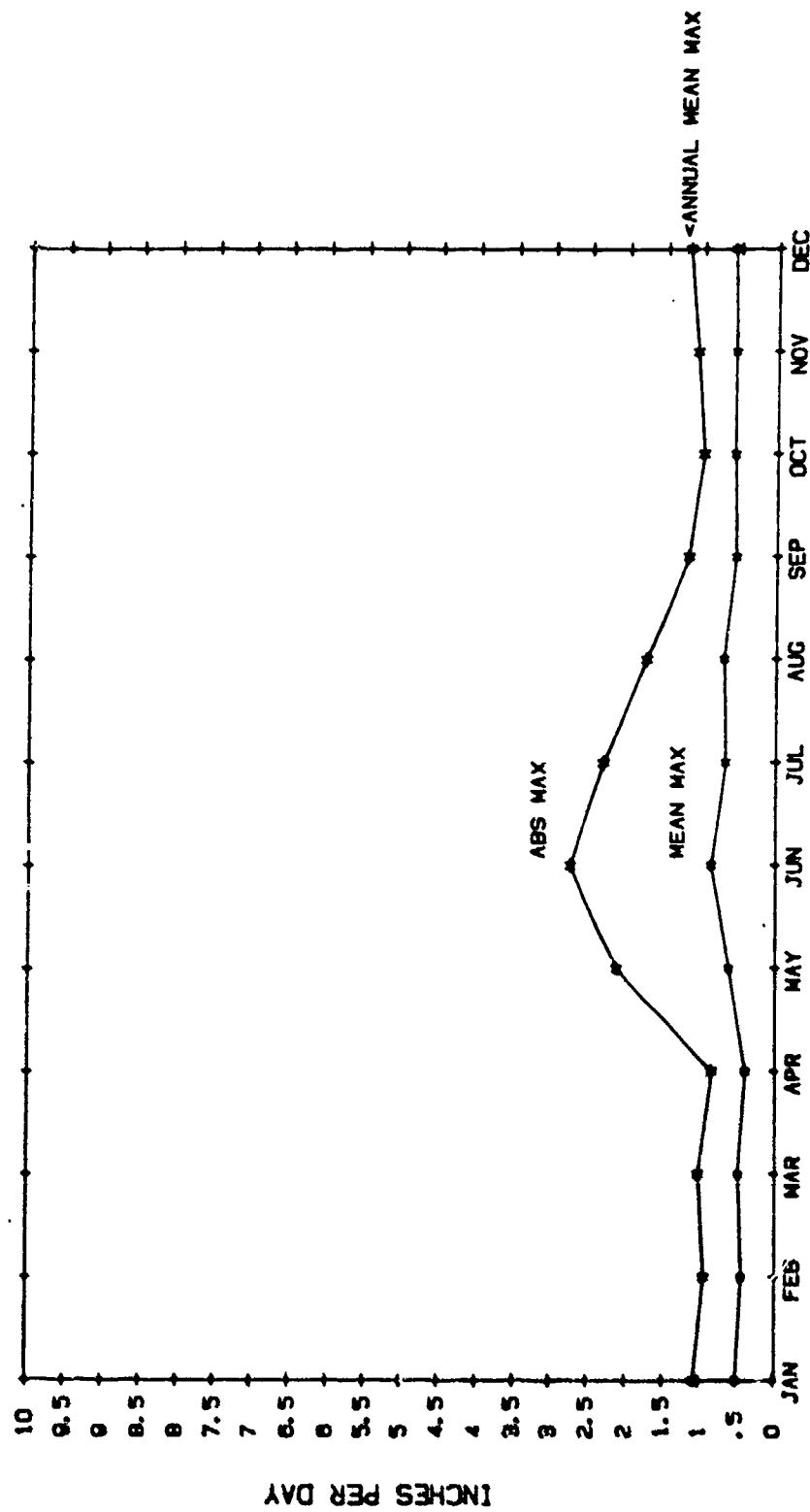


Figure A-78. Maximum Amounts of Daily Precipitation, Upper Heyford.

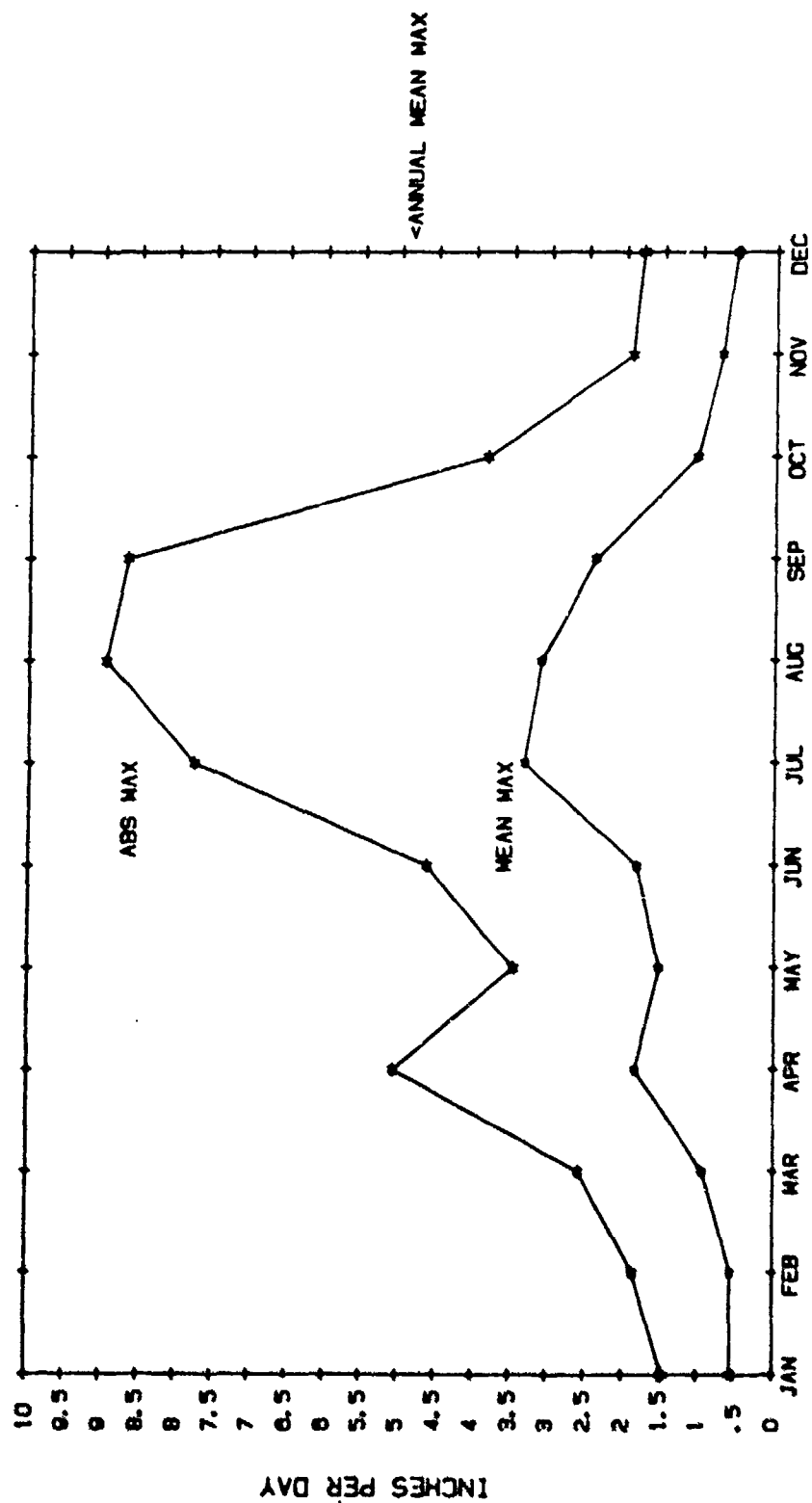


Figure A-79. Maximum Amounts of Daily Precipitation, Korea: Mean of Osan and Kunsan.

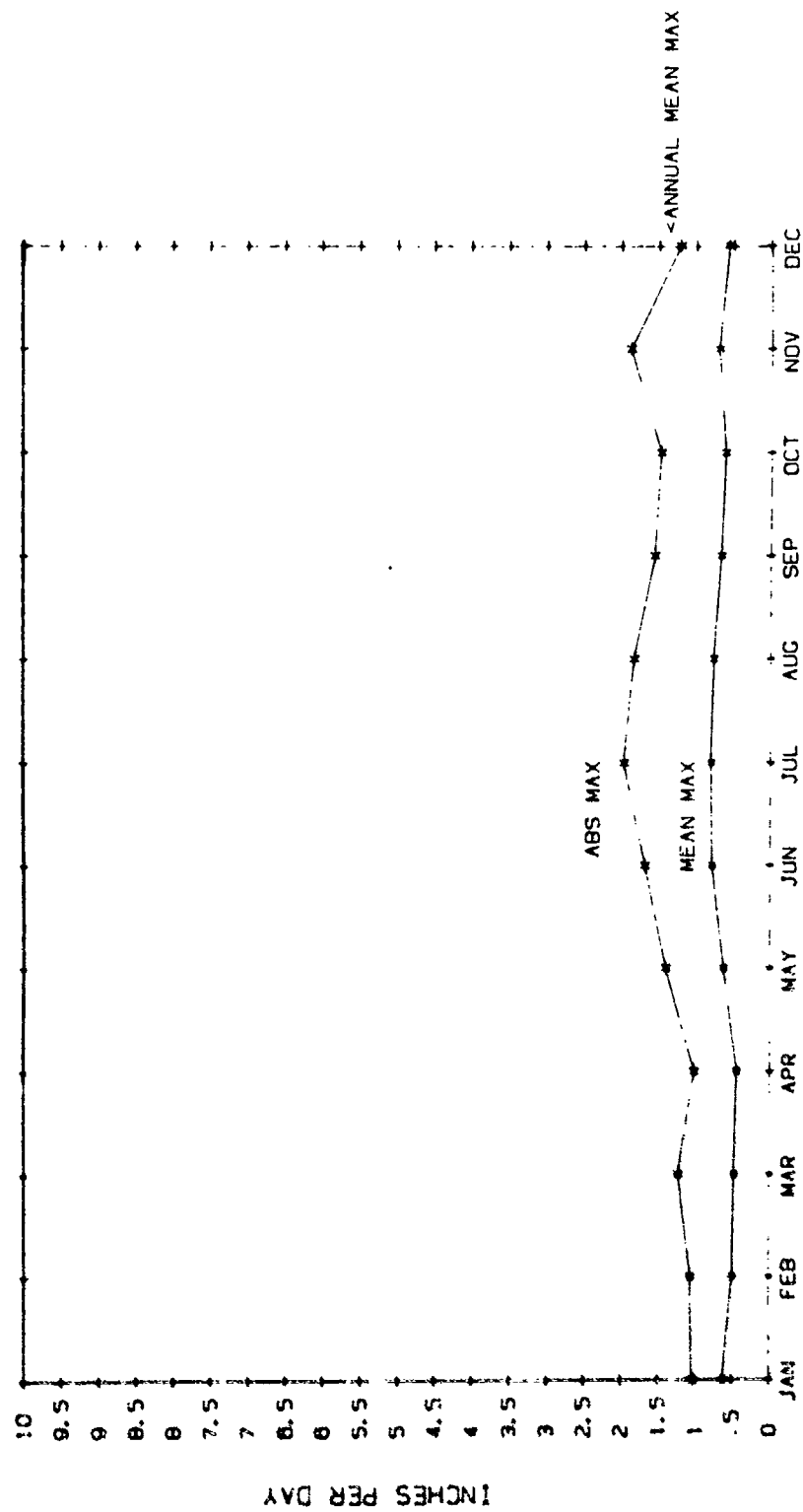


Figure A-80. Maximum Amounts of Daily Precipitation, Mean of German Airbases.

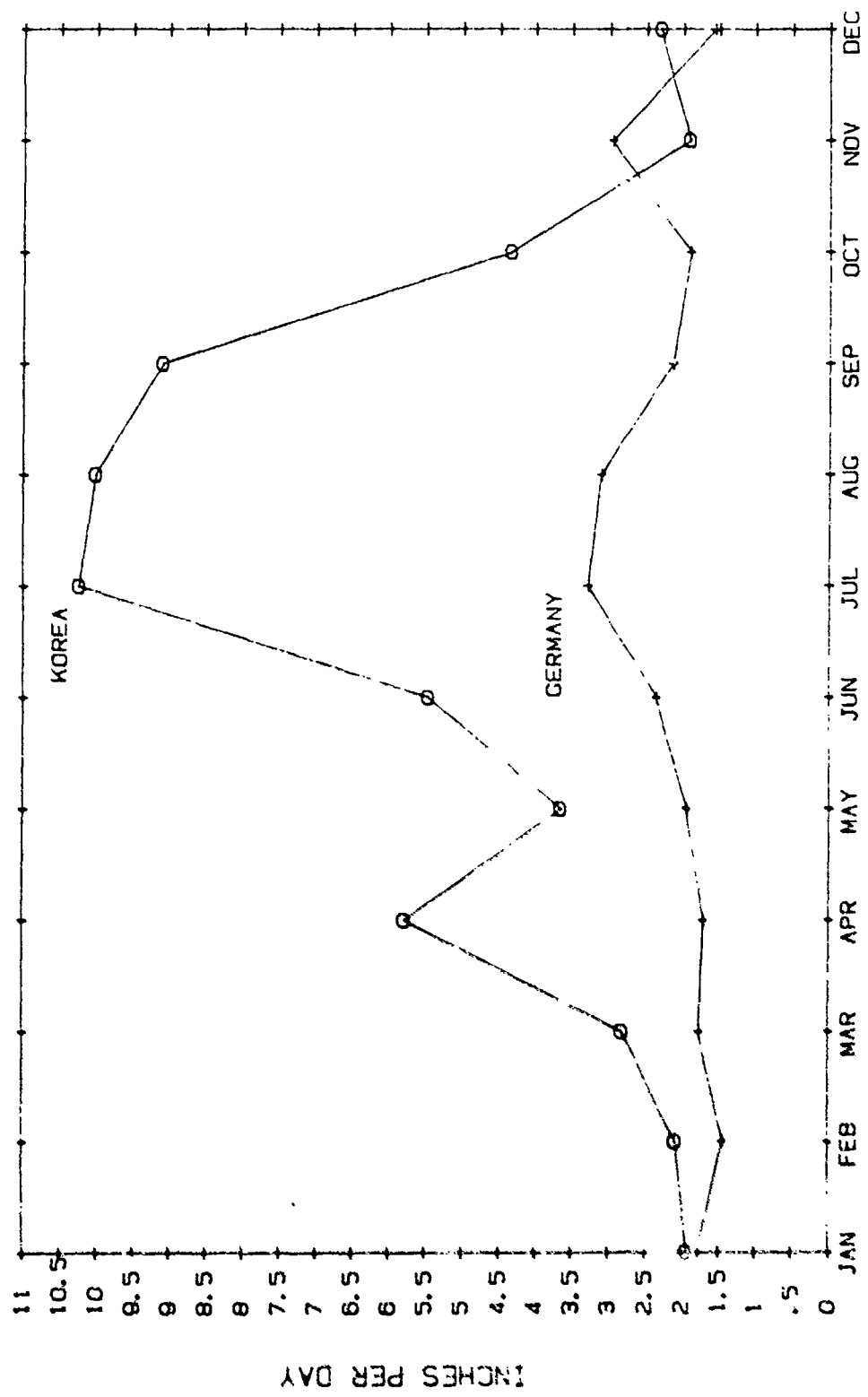


Figure A-81. Maximum Amounts of Daily Precipitation, Worst Case: Korea and Germany.

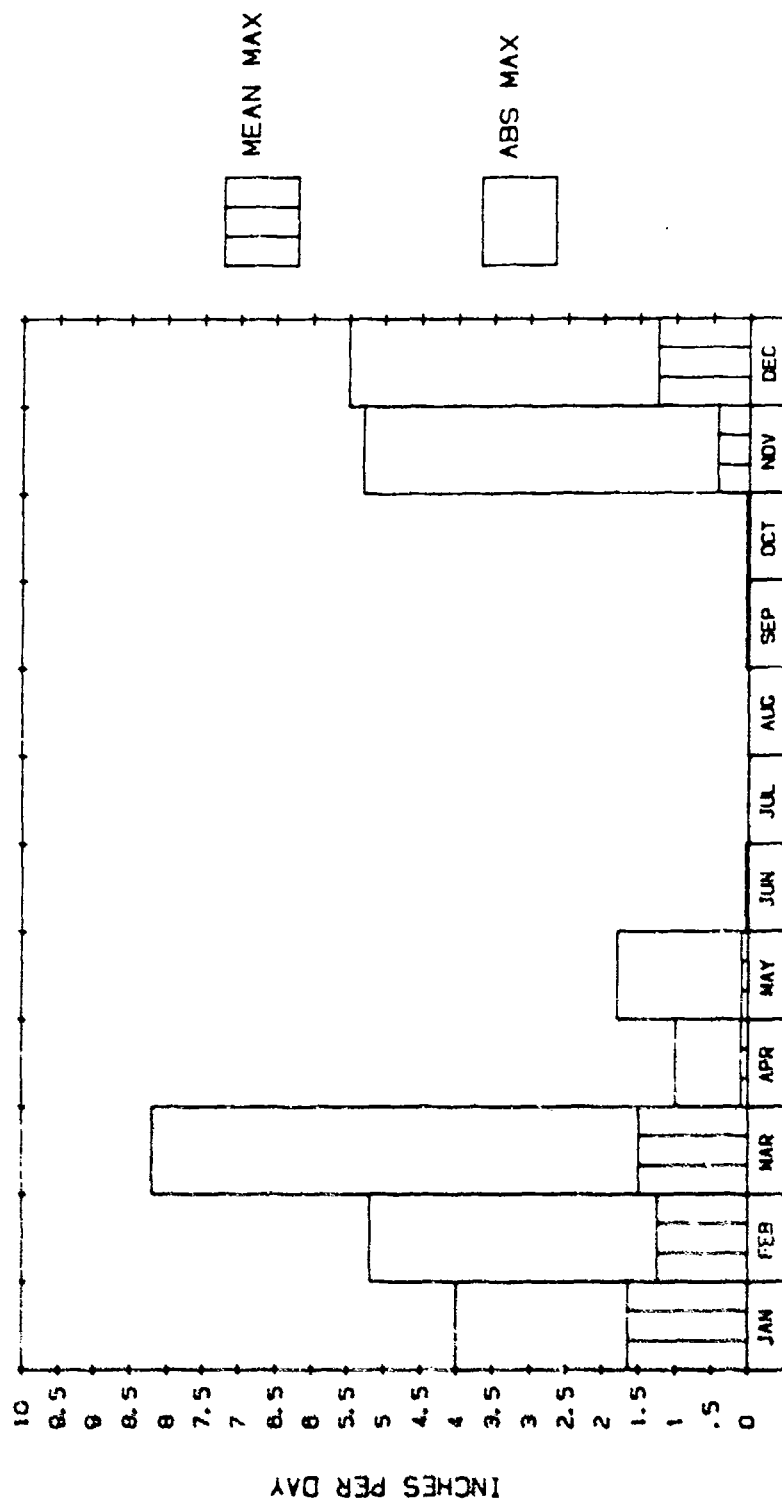


Figure A-82. Maximum Amounts of Daily Snowfall, Upper Heyford.

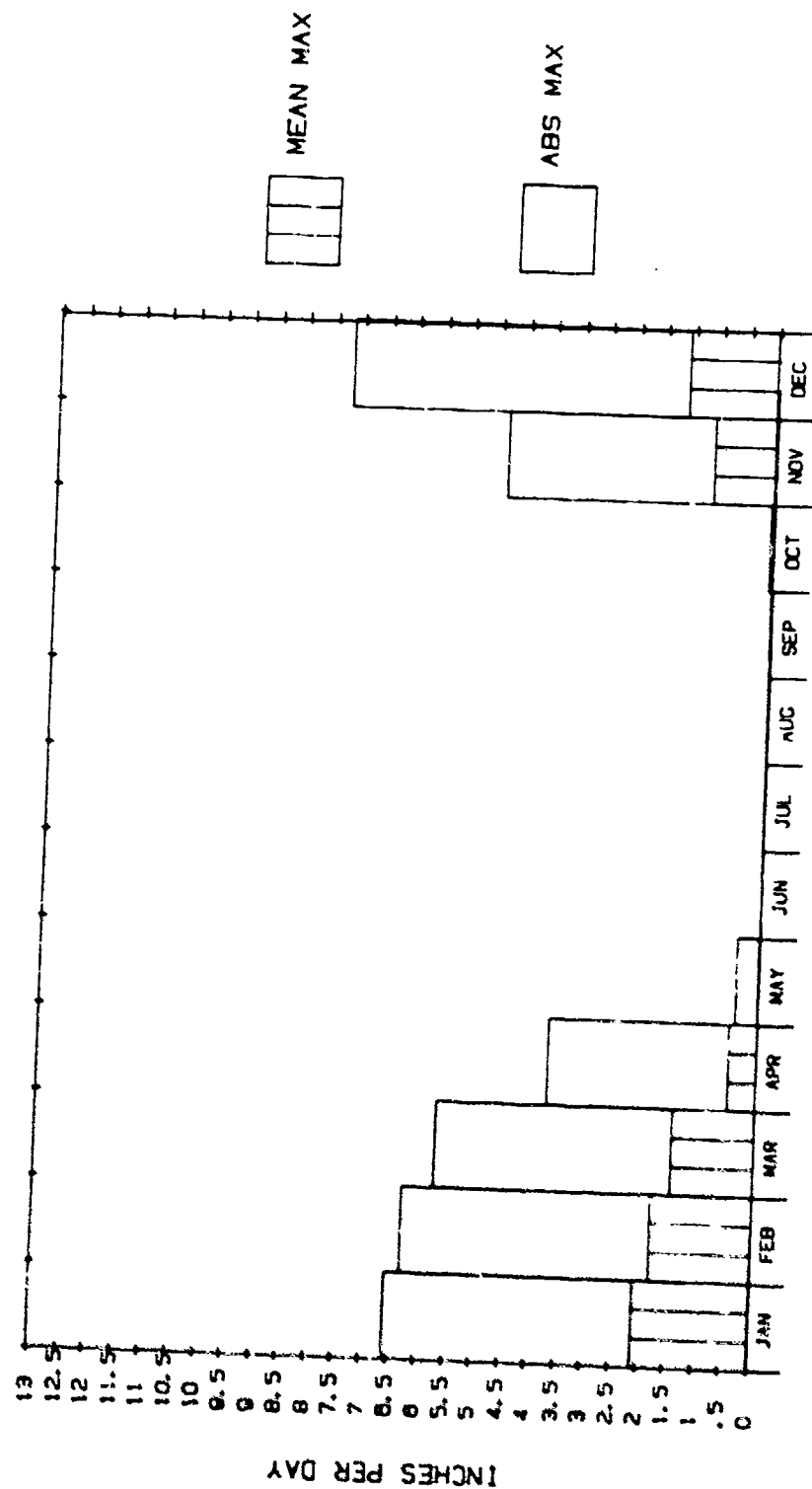


Figure A-83. Maximum Amounts of Daily Snowfall, Mean of German Airbases.

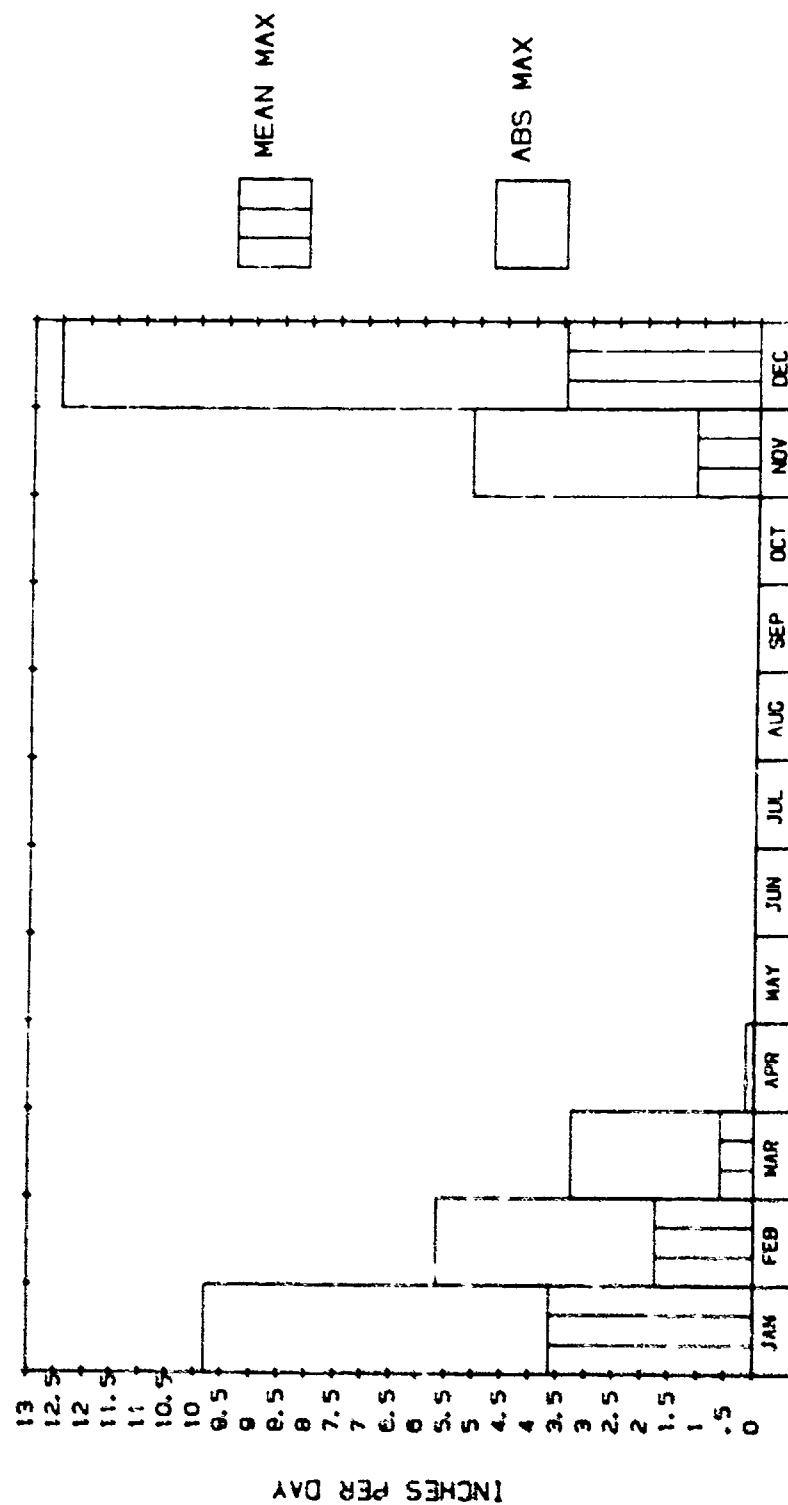


Figure A-84. Maximum Amounts of Daily Snowfall, Korea: Mean of Osan and Kunsan.

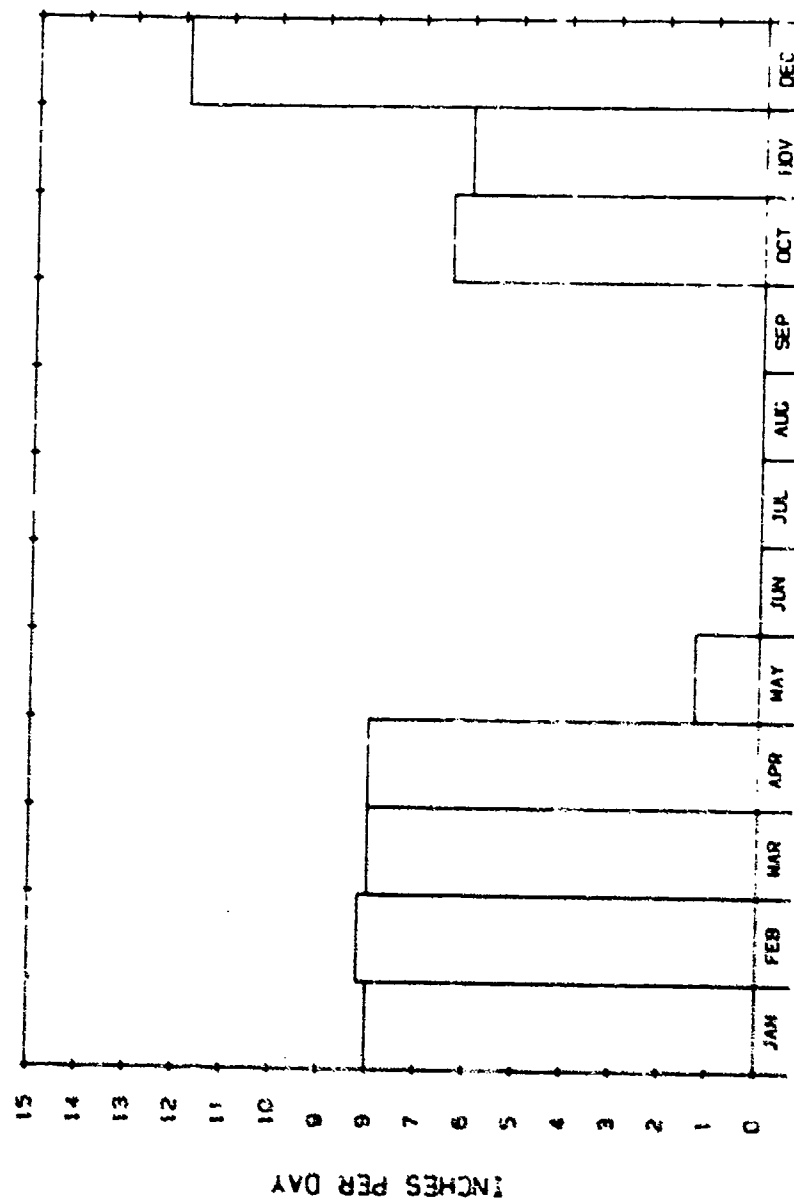


Figure A-85. Maximum Amounts of Daily Snowfall, Worst Case: Germany.

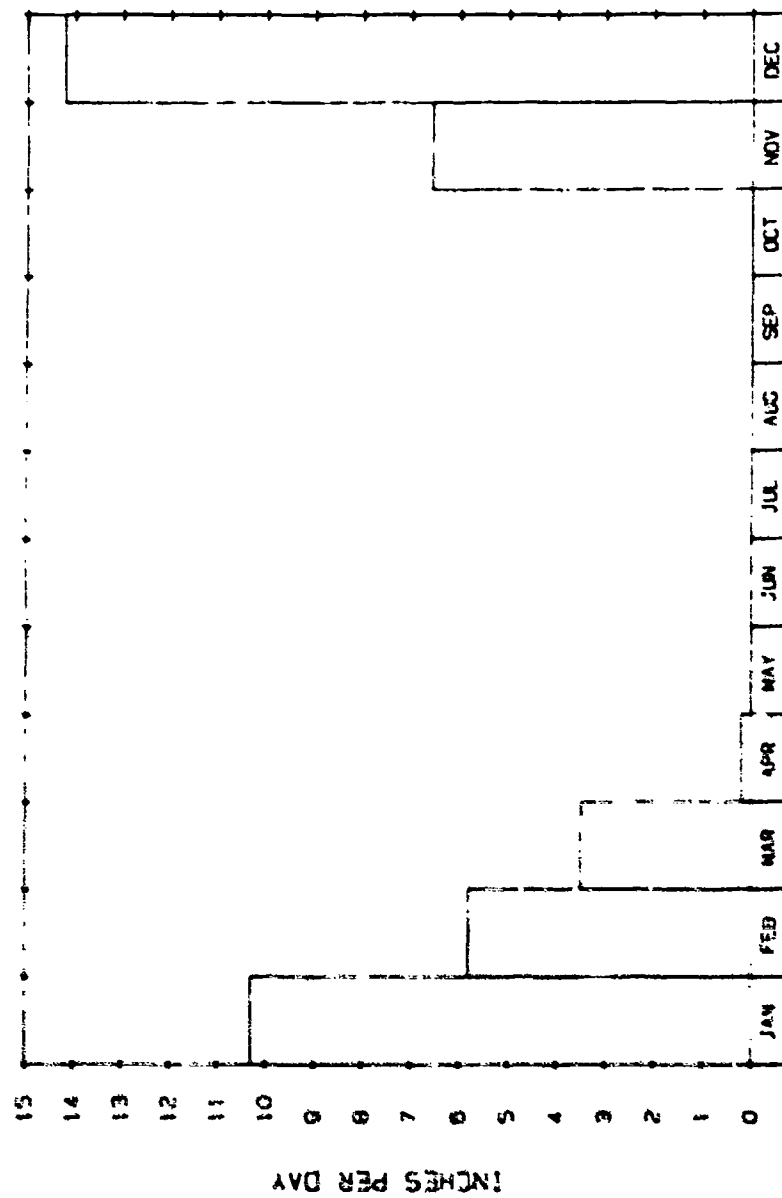


Figure A-86. Maximum Amounts of Daily Snowfall, Worst Case: Korea.

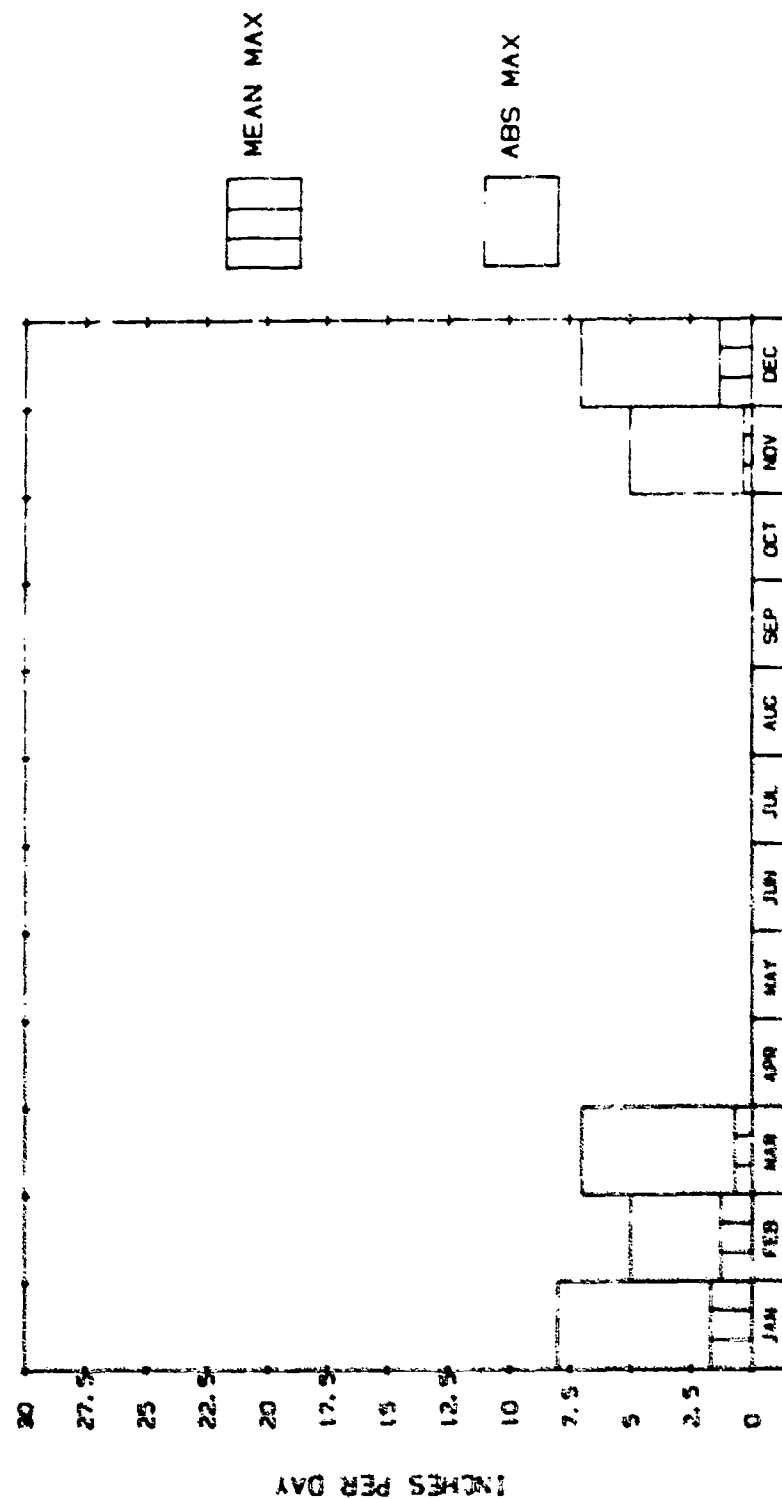


Figure A-87. Maximum Amounts of Daily Snowdepth, Upper Heyford.

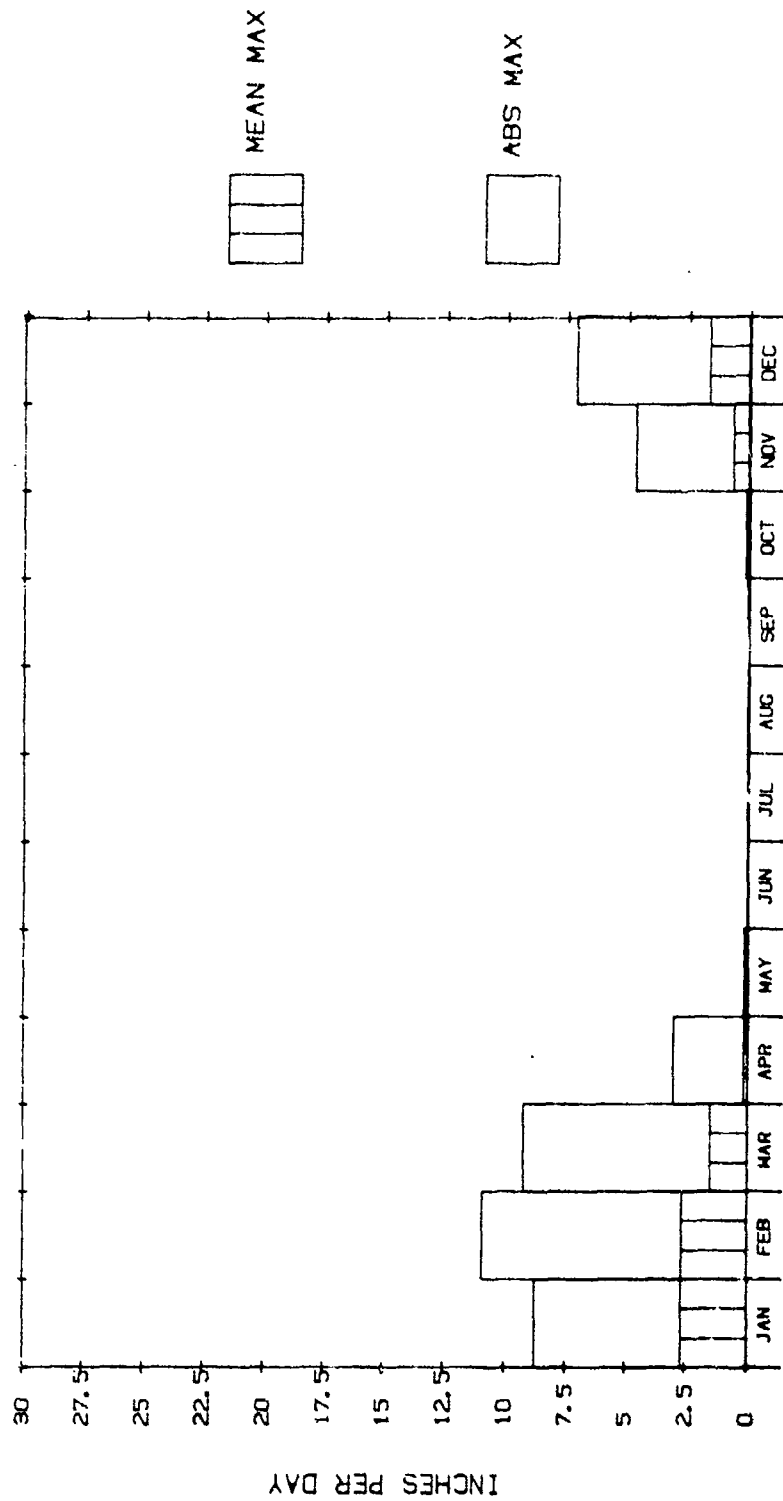


Figure A-58. Maximum Amounts of Daily Snowdepth, Mean of German Airbases.

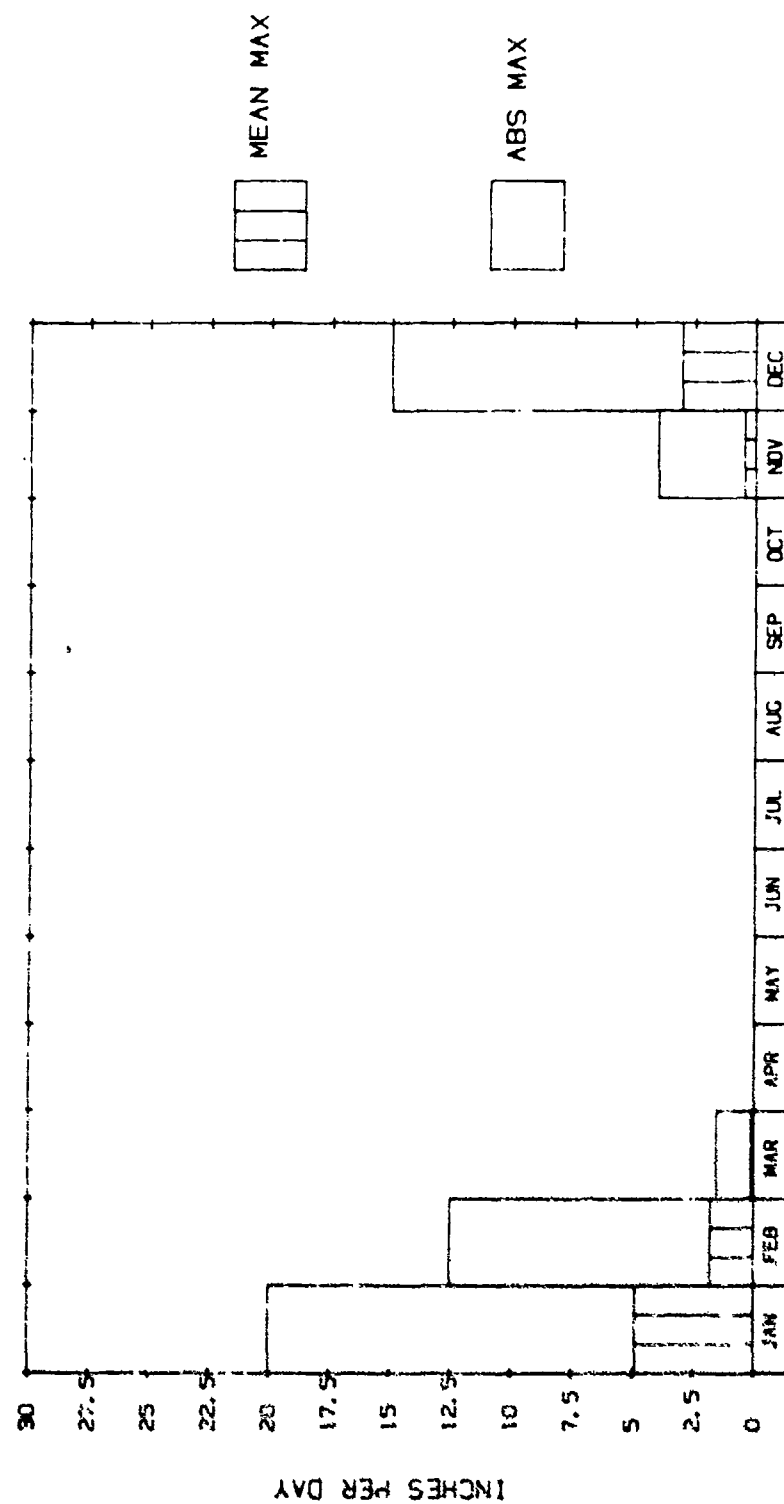


Figure A-89. Maximum Amounts of Daily Snowdepth, Korea: Mean of Osan and Kunsan.

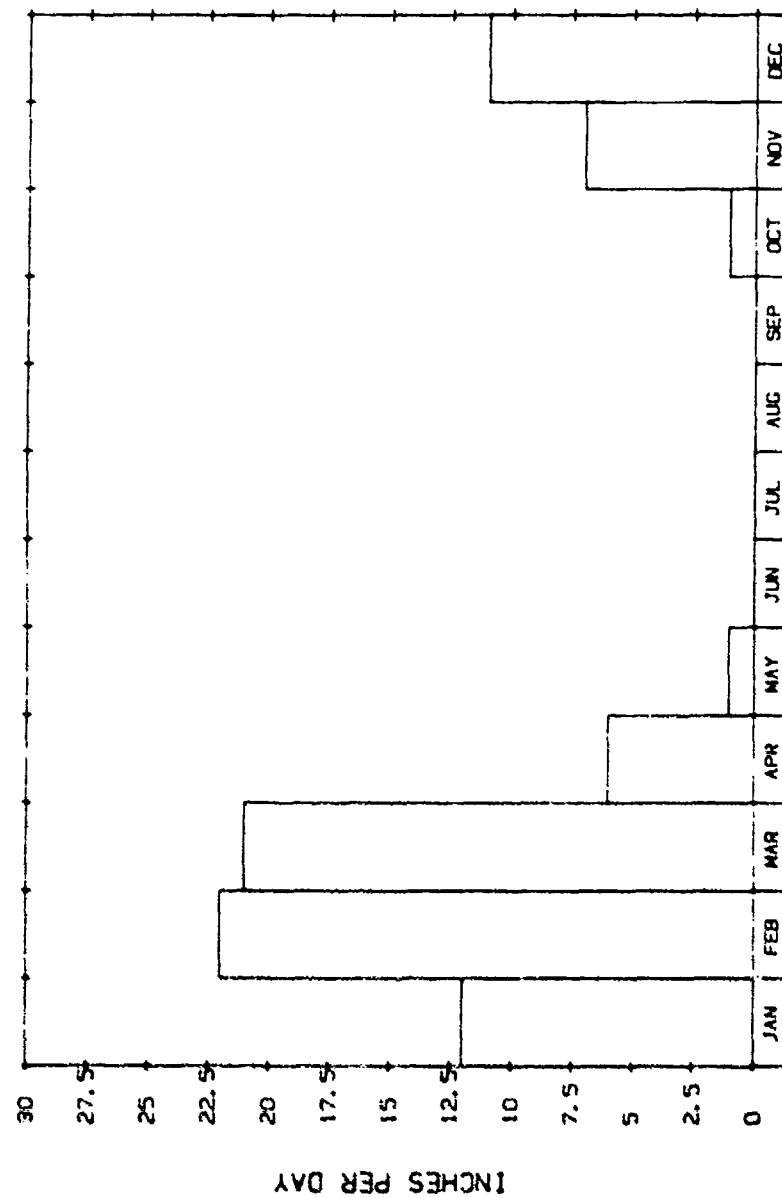


Figure A-90. Maximum Amounts of Daily Snowdepth, Worst Case: Germany.

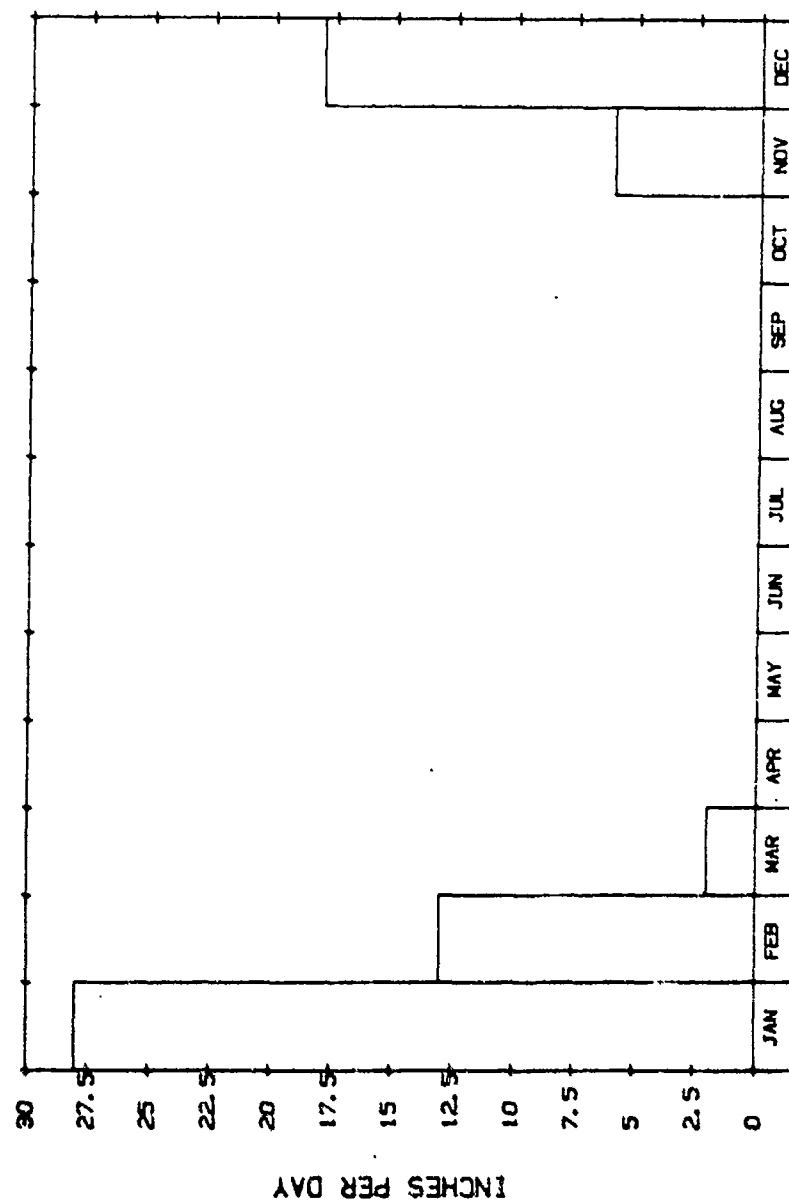


Figure A-91. Maximum Amounts of Daily Snowdepth, Worst Case: Korea.

c. Daily Amounts of Precipitation/Snowfall/Snowdepth

For each airbase in a theater, the amount of precipitation was measured at hourly intervals. These data were combined into 24-hour groups to determine daily precipitation levels. This set of graphs indicates daily occurrences of precipitation by month. The statistics for each airbase are calculated by determining the percentage of recorded observations that fall within each range of precipitation levels. These probabilities were then averaged across each theater.

Similar arguments can be made for snowfall and snowdepth.

Note that Figures A-116 to A-127 represent only Osan Airbase, Korea since data were unavailable for Kunsan Airbase in this category.

EXAMPLE: Consider Upper Heyford in January (Figure A-92). Approximately 29 percent of the days recorded received no precipitation, 21 percent received only a trace and 1 percent received from .51 to 1.0 inches.

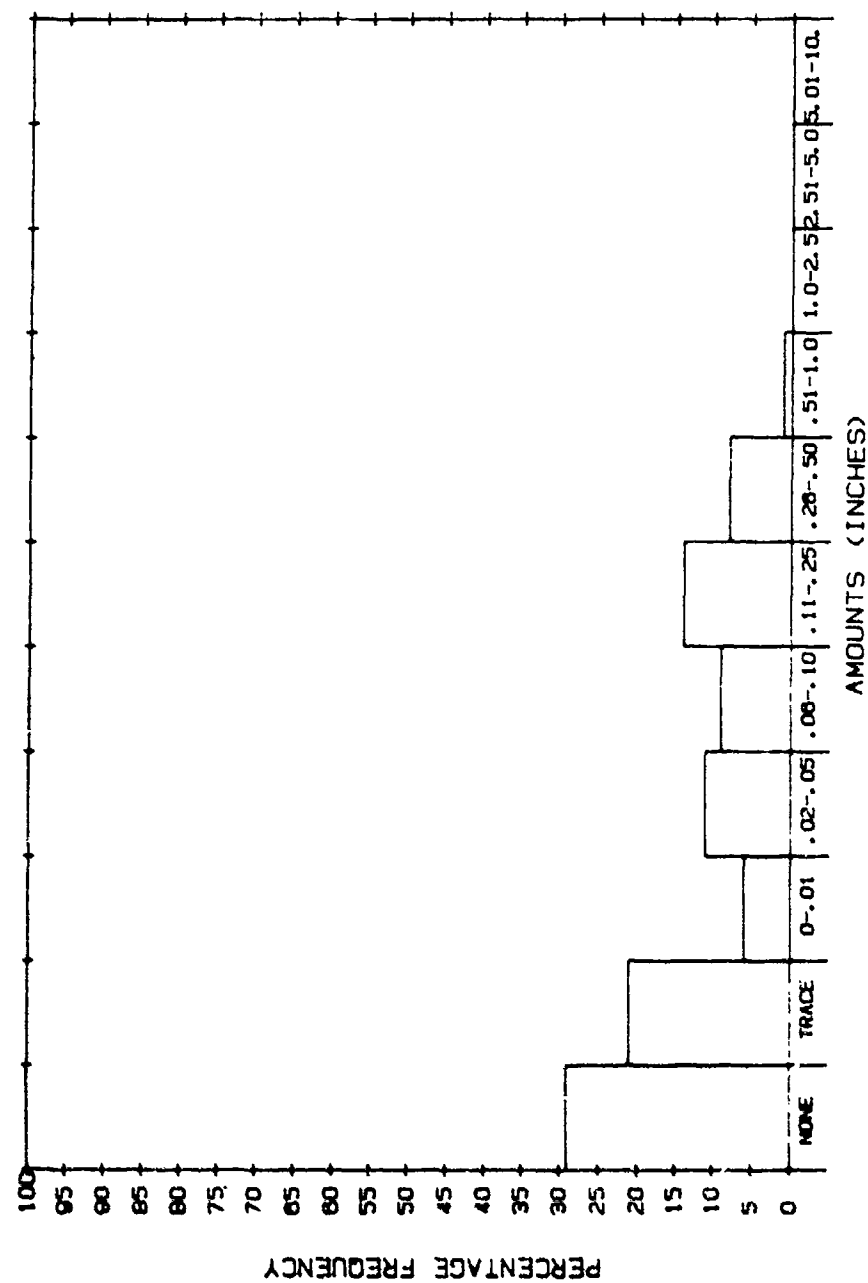


Figure A-92. Daily Amounts of Precipitation, Upper Heyford in January.

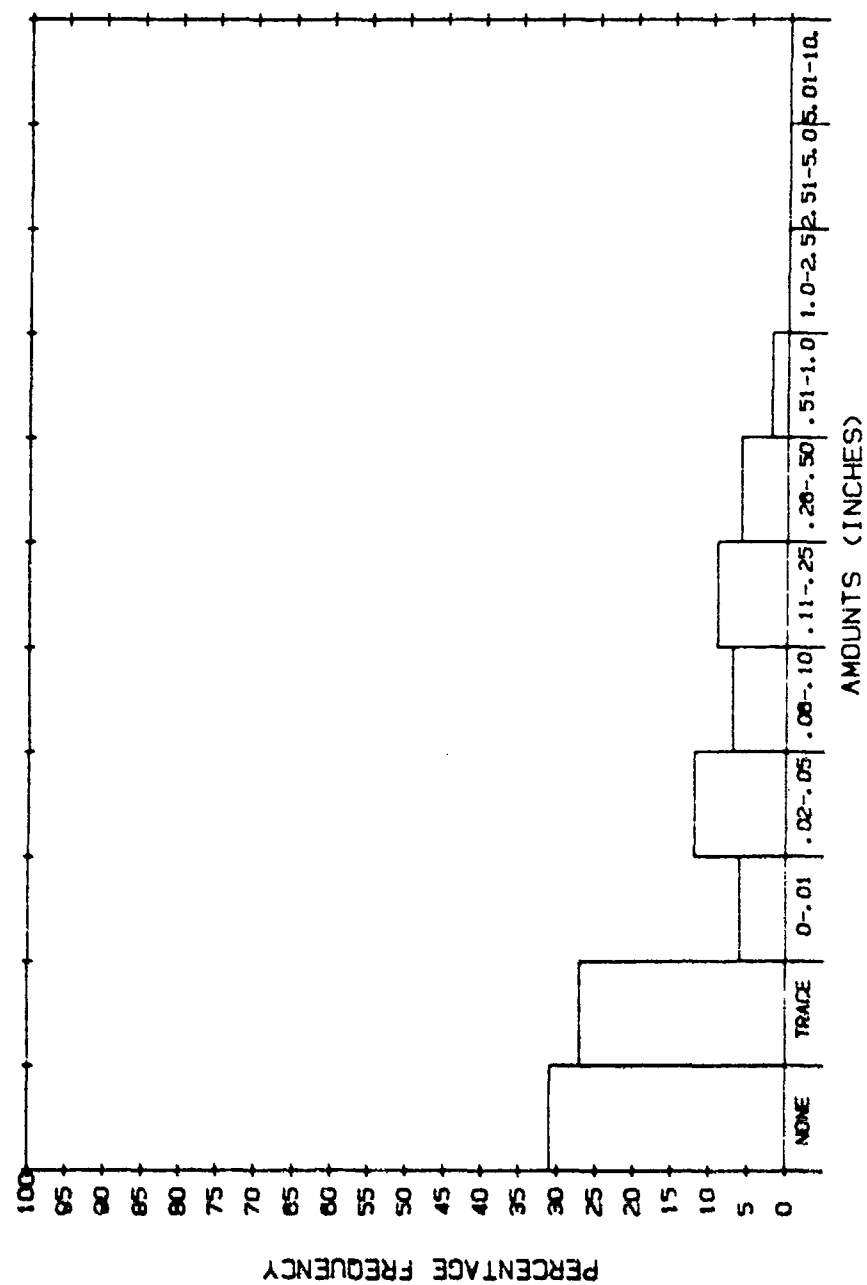


Figure A-93. Daily Amounts of Precipitation, Upper Heyford in February.

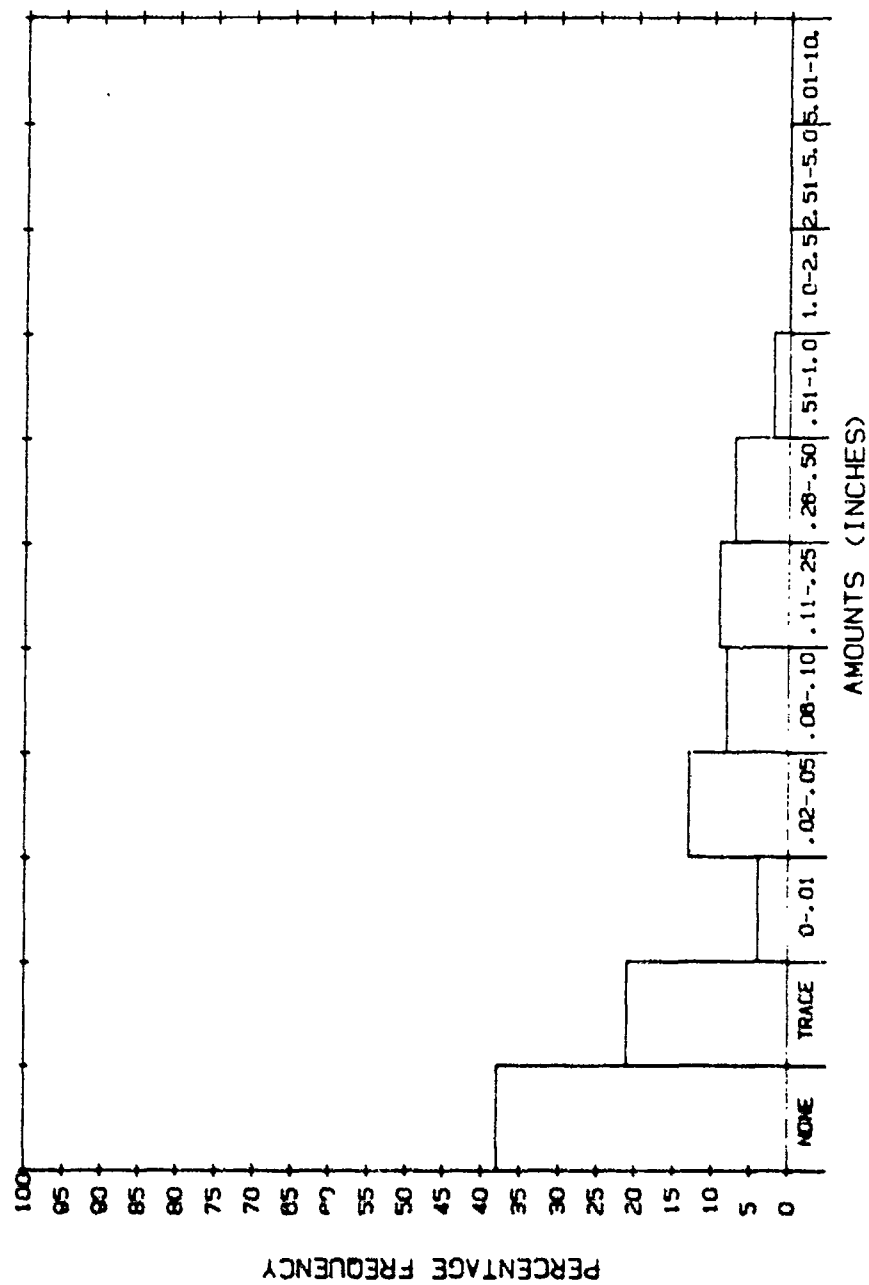


Figure A-94. Daily Amounts of Precipitation, Upper Heyford in March.

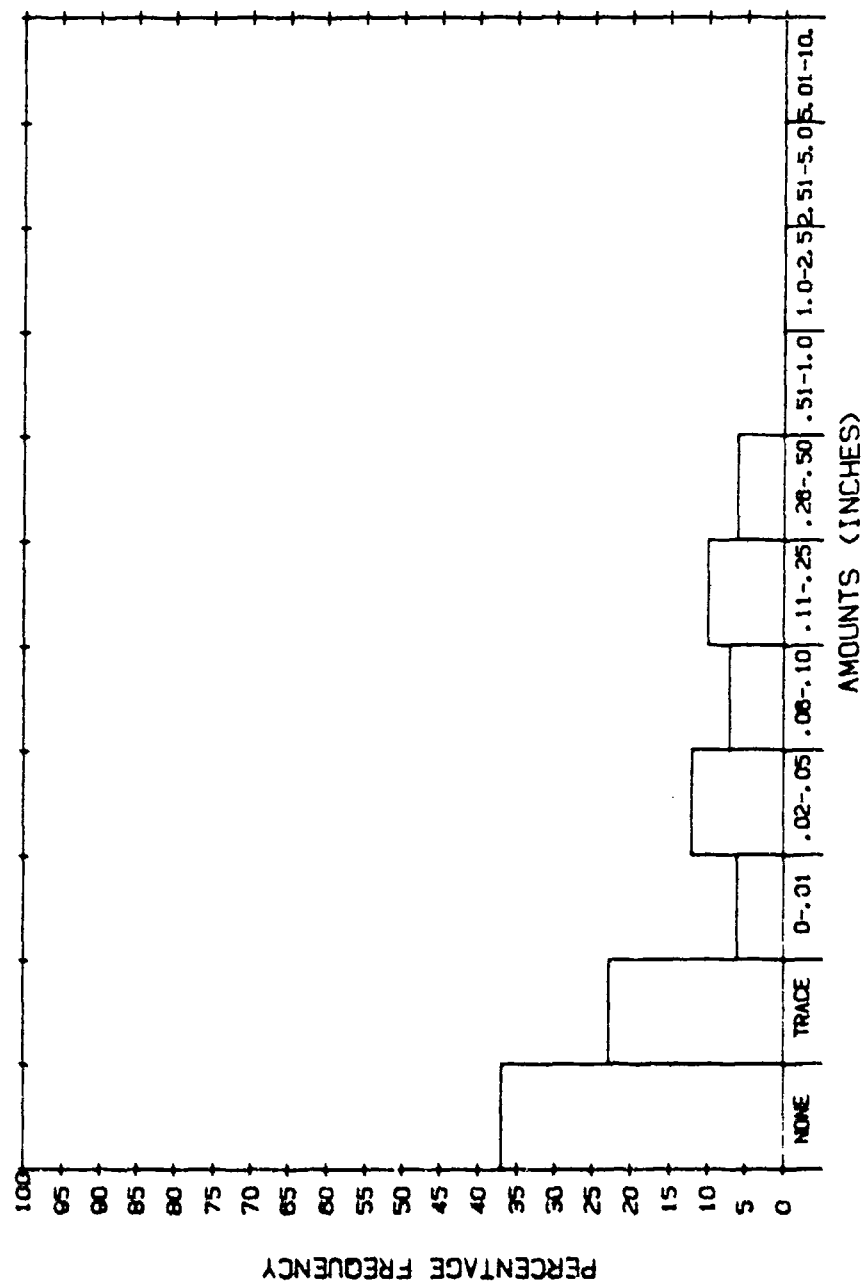


Figure A-95. Daily Amounts of Precipitation, Upper Heyford in April.

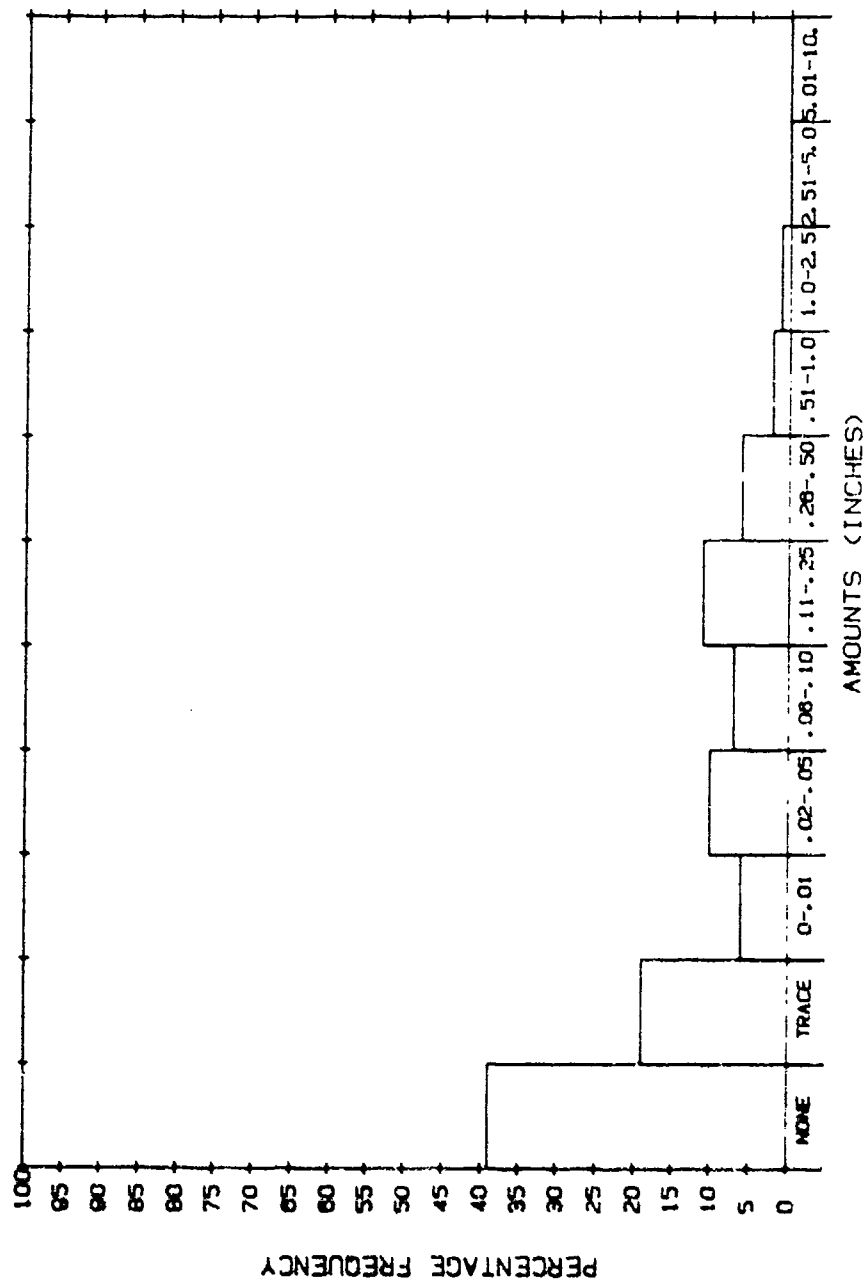


Figure A-96. Daily Amounts of Precipitation, Upper Heyford in May.

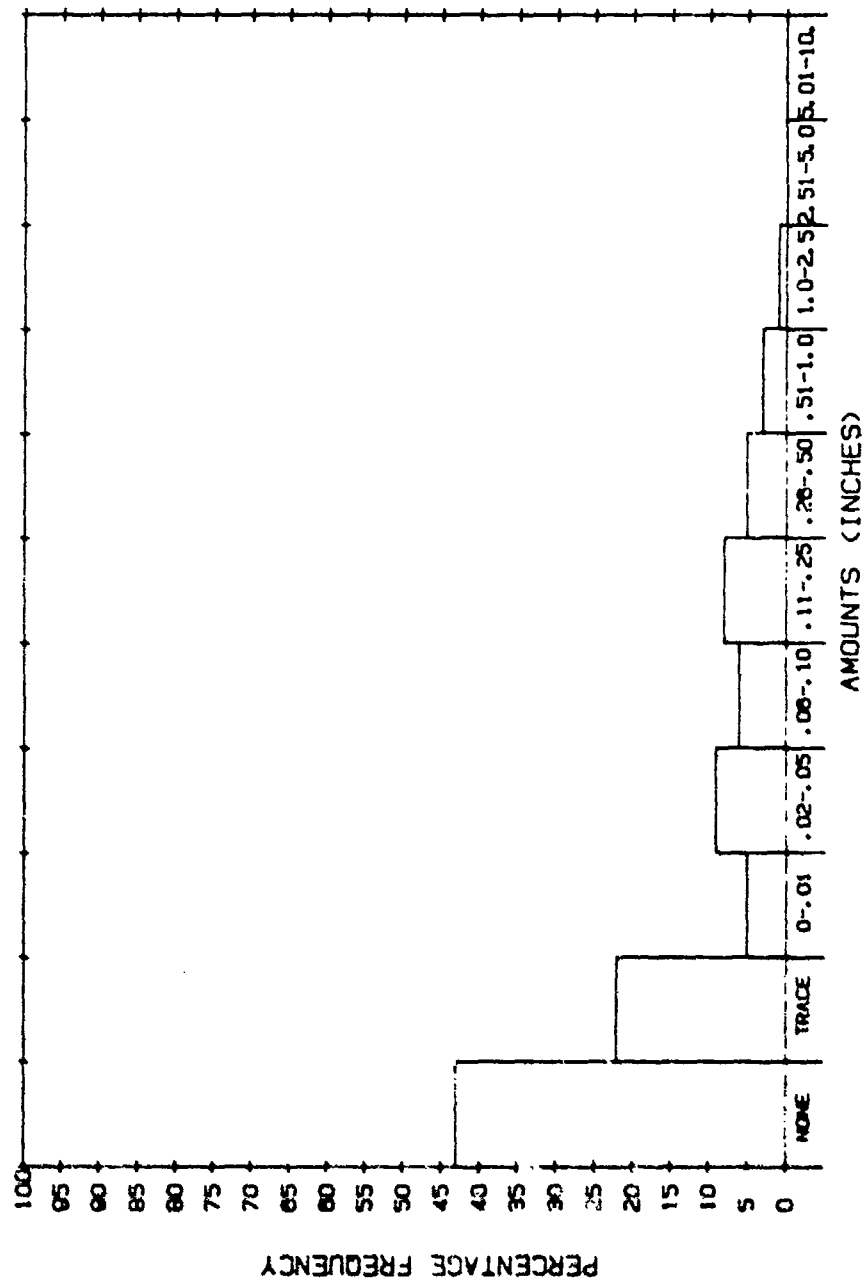


Figure A-97. Daily Amounts of Precipitation, Upper Heyford in June.

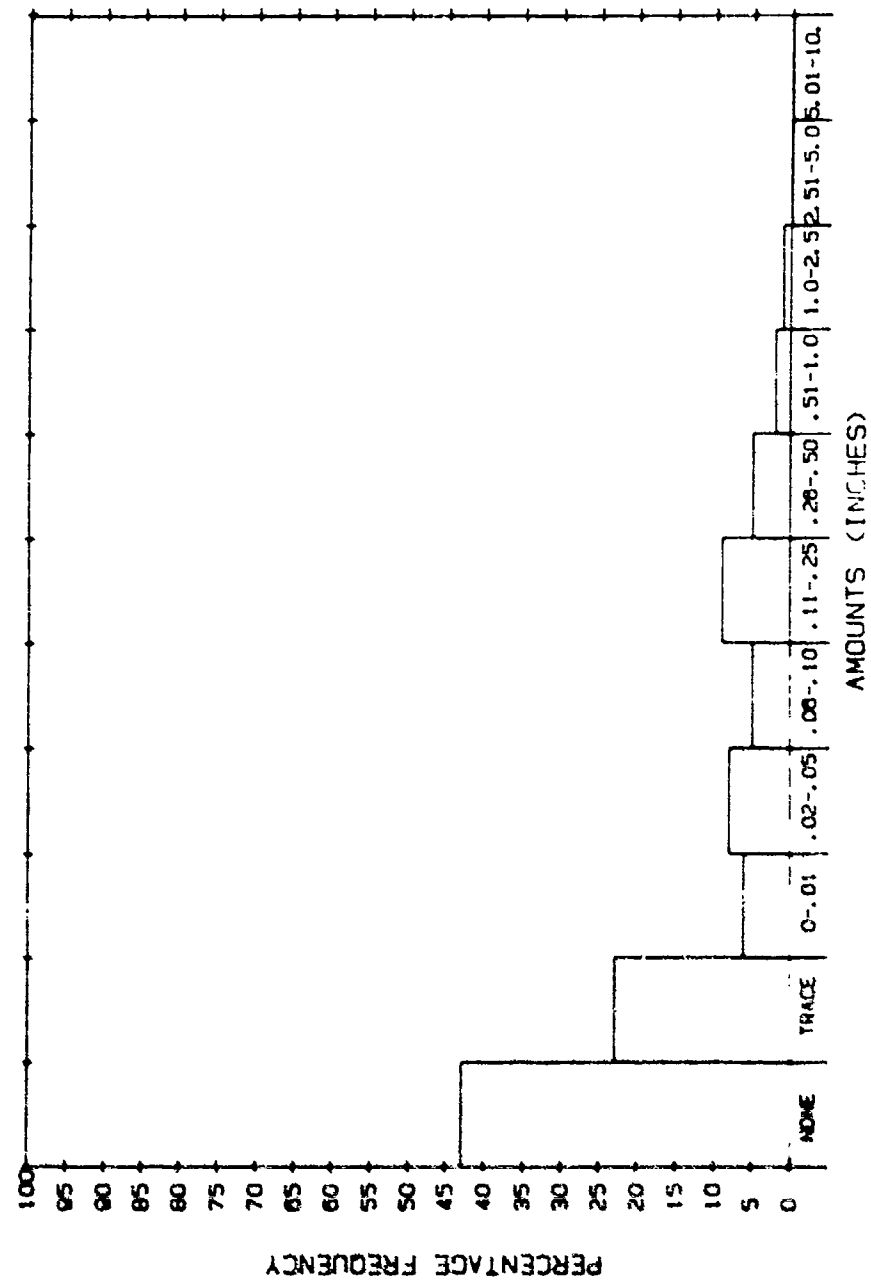


Figure A-32. Daily Amounts of Precipitation, Upper Heyford in July.

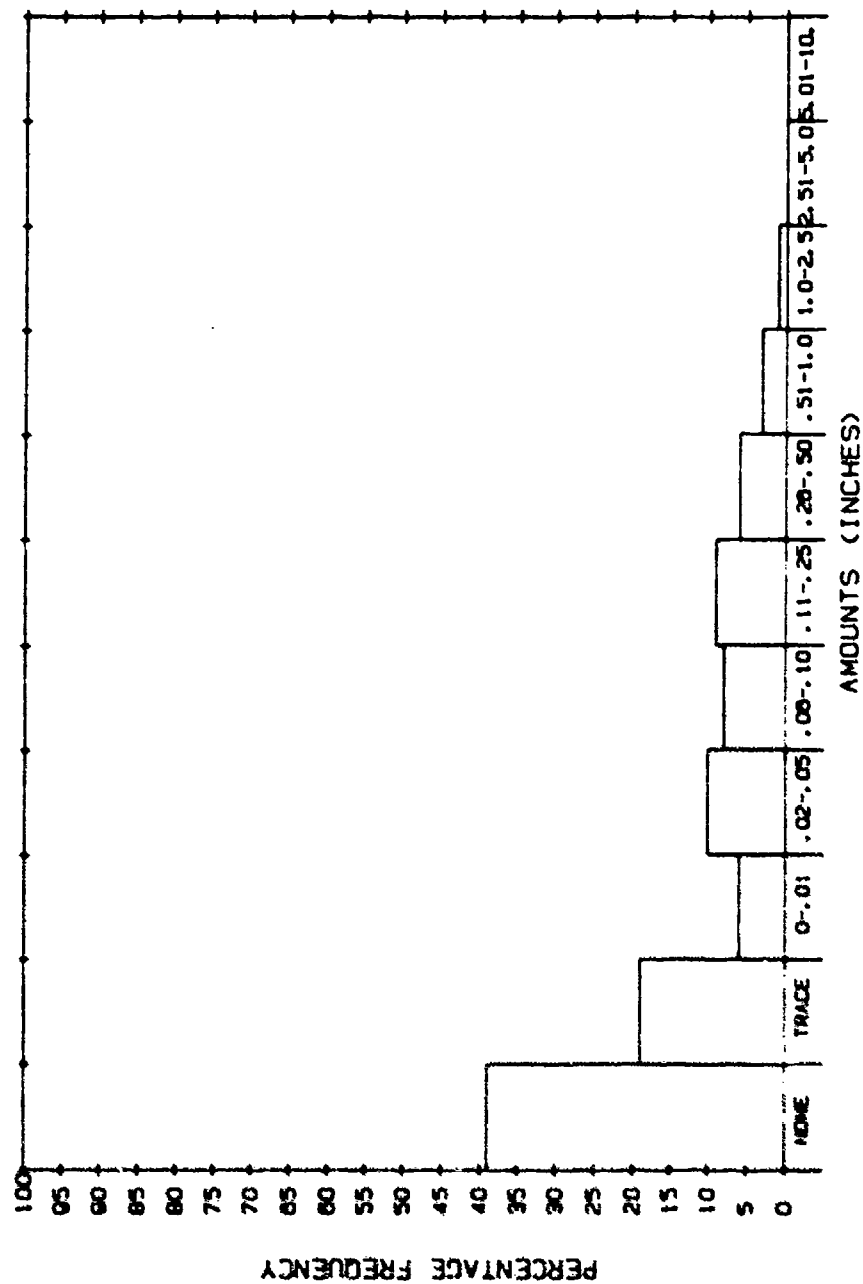


Figure A-99. Daily Amounts of Precipitation, Upper Heyford in August.

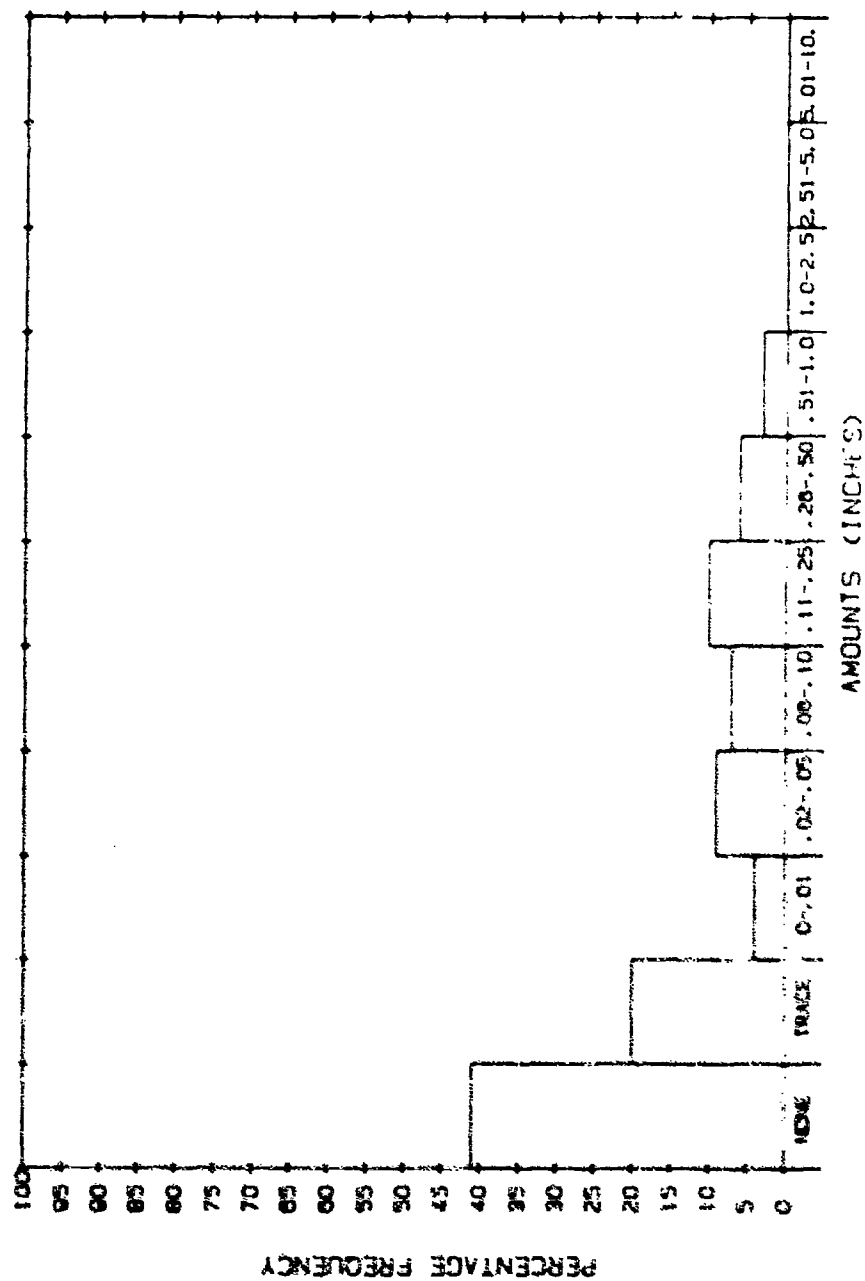


Figure A-100. Daily Amounts of Precipitation, Upper Heyford in September.

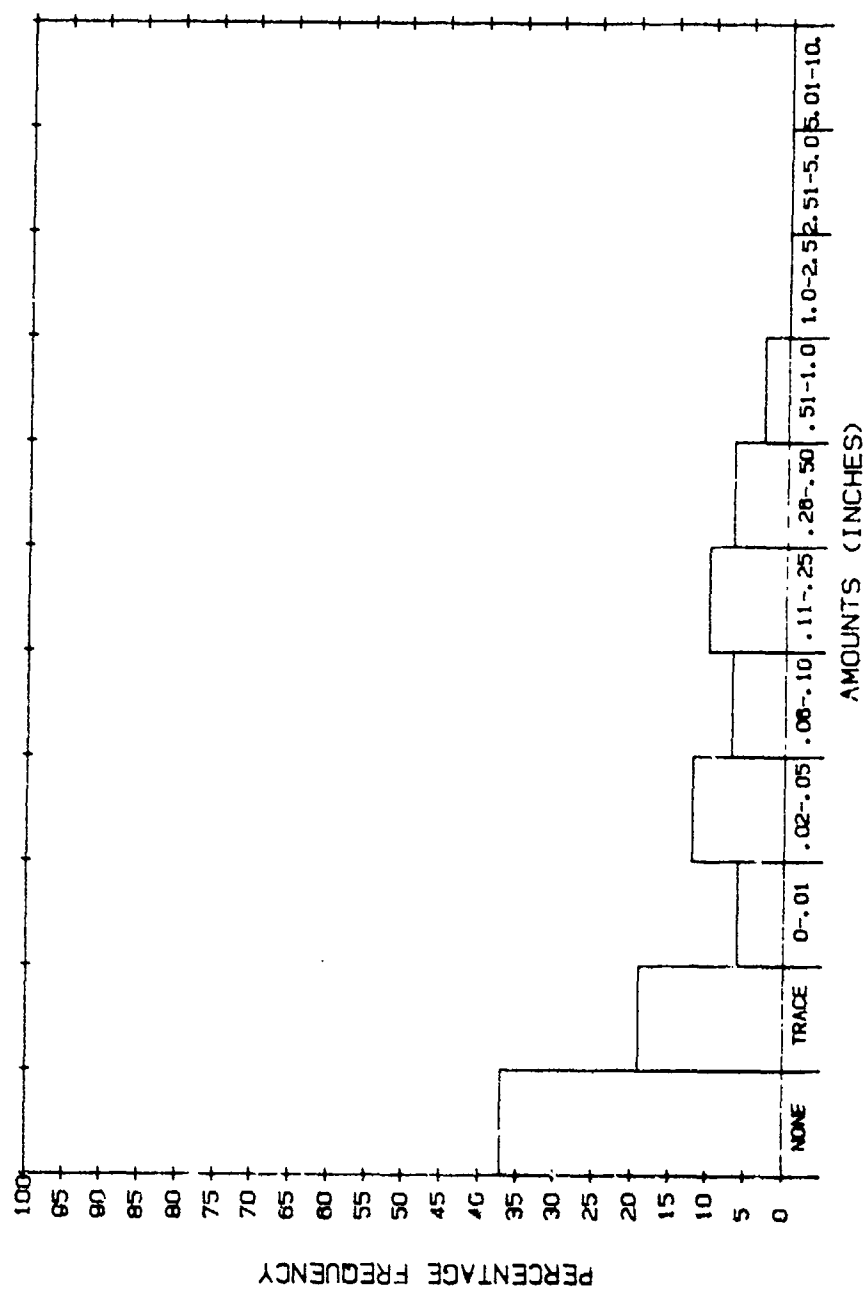


Figure A-101. Daily Amounts of Precipitation, Upper Heyford in October.

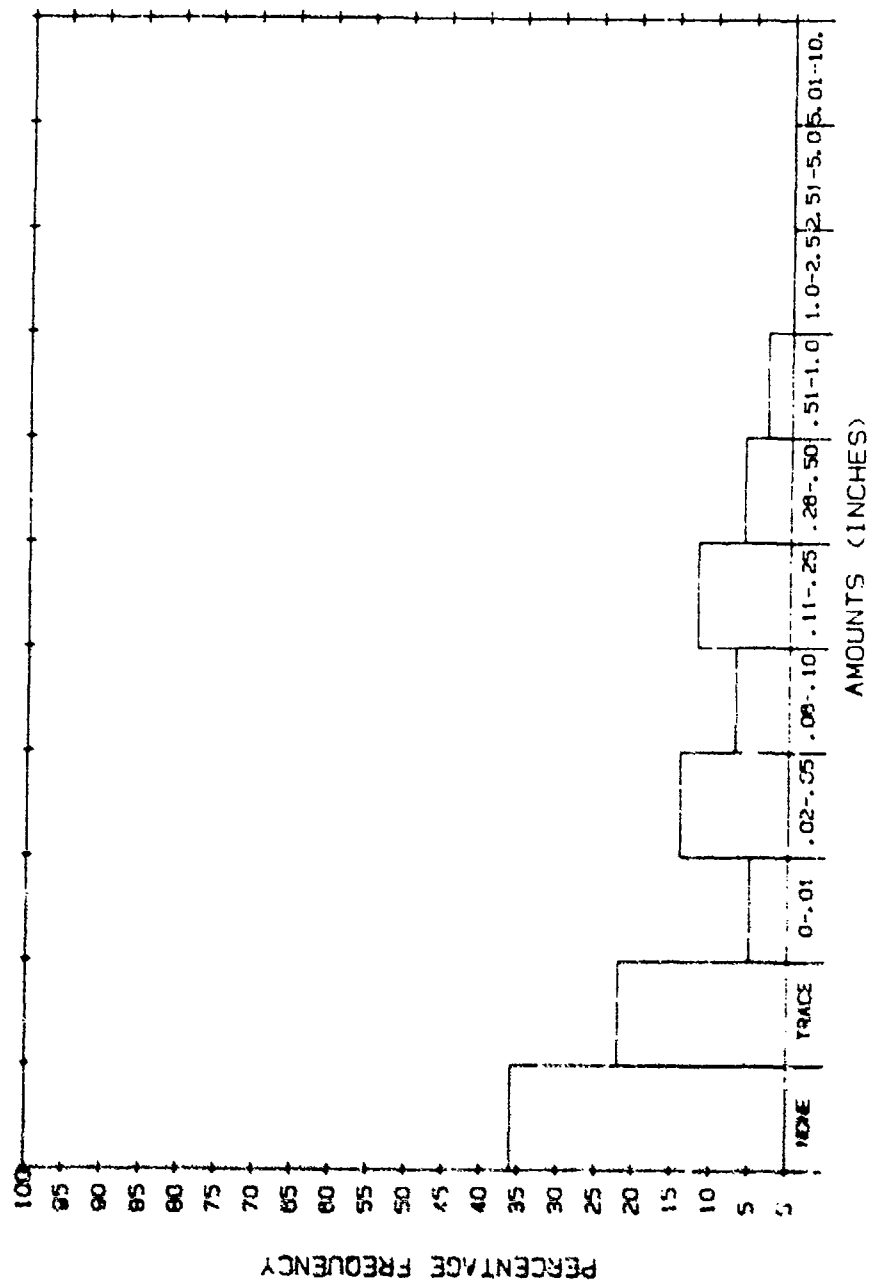


Figure A-102. Daily Amounts of Precipitation, Upper Heyford in November.

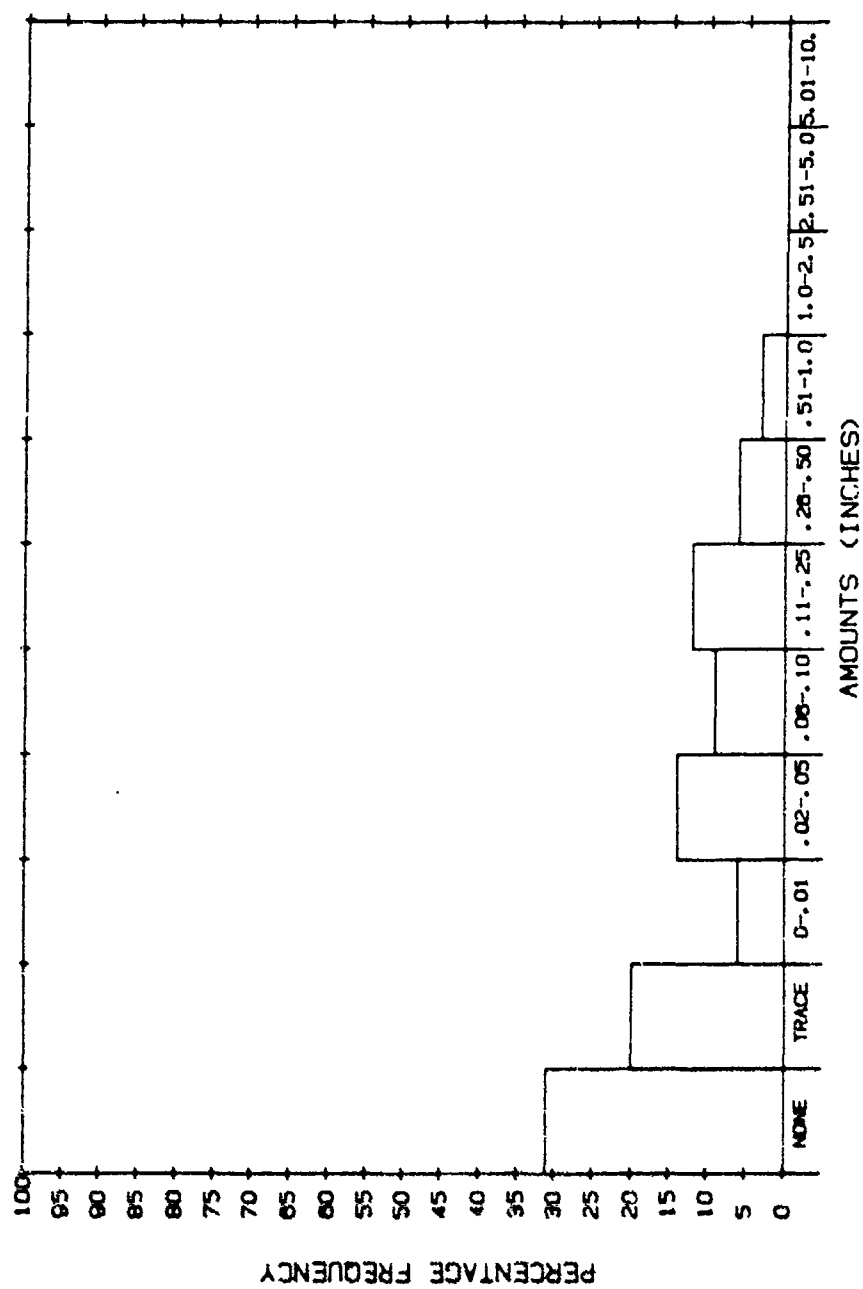


Figure A-103. Daily Amounts of Precipitation, Upper Heyford in December.

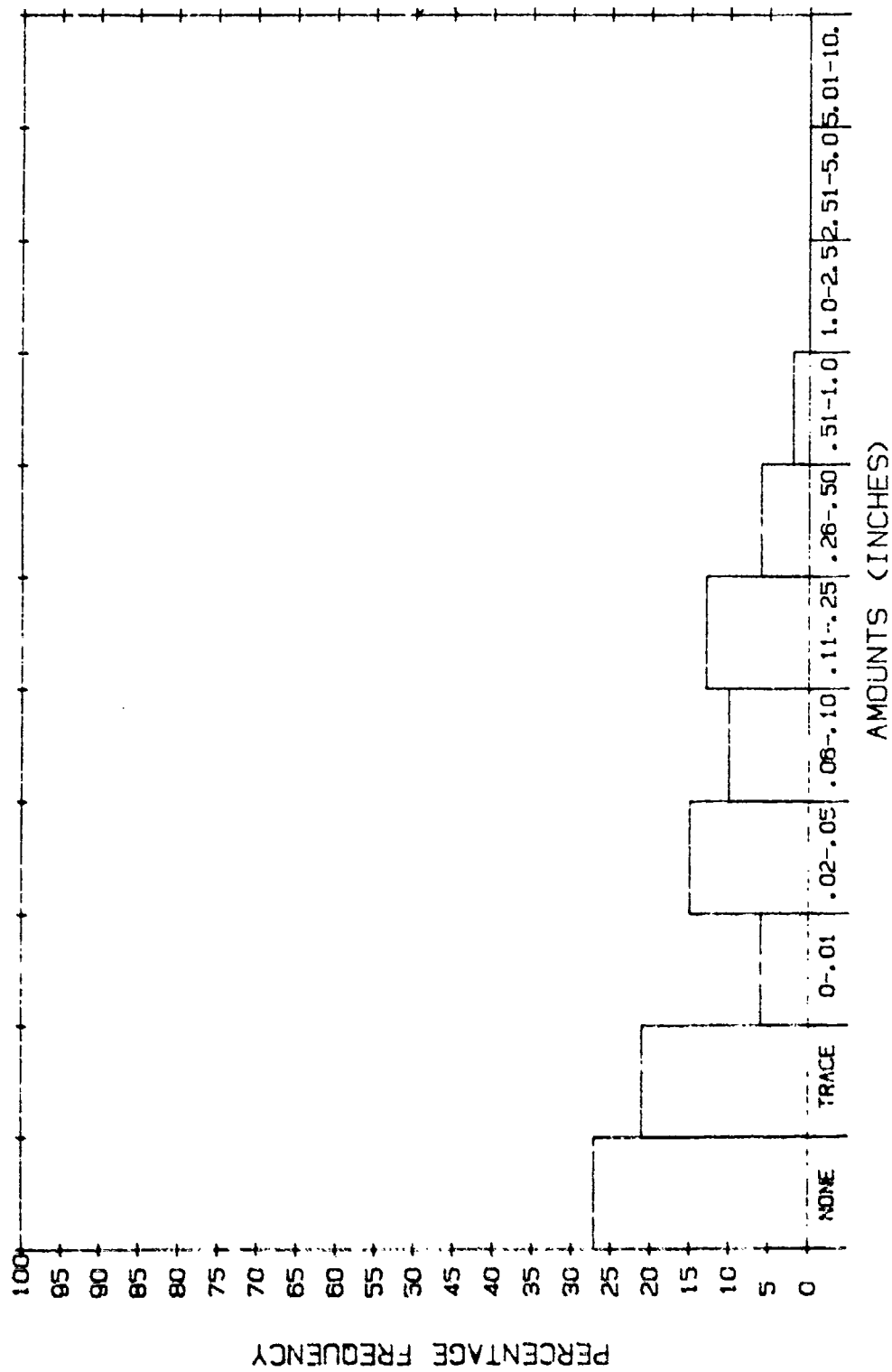


Figure A-104. Daily Amounts of Precipitation, Mean of German Airbases in January.

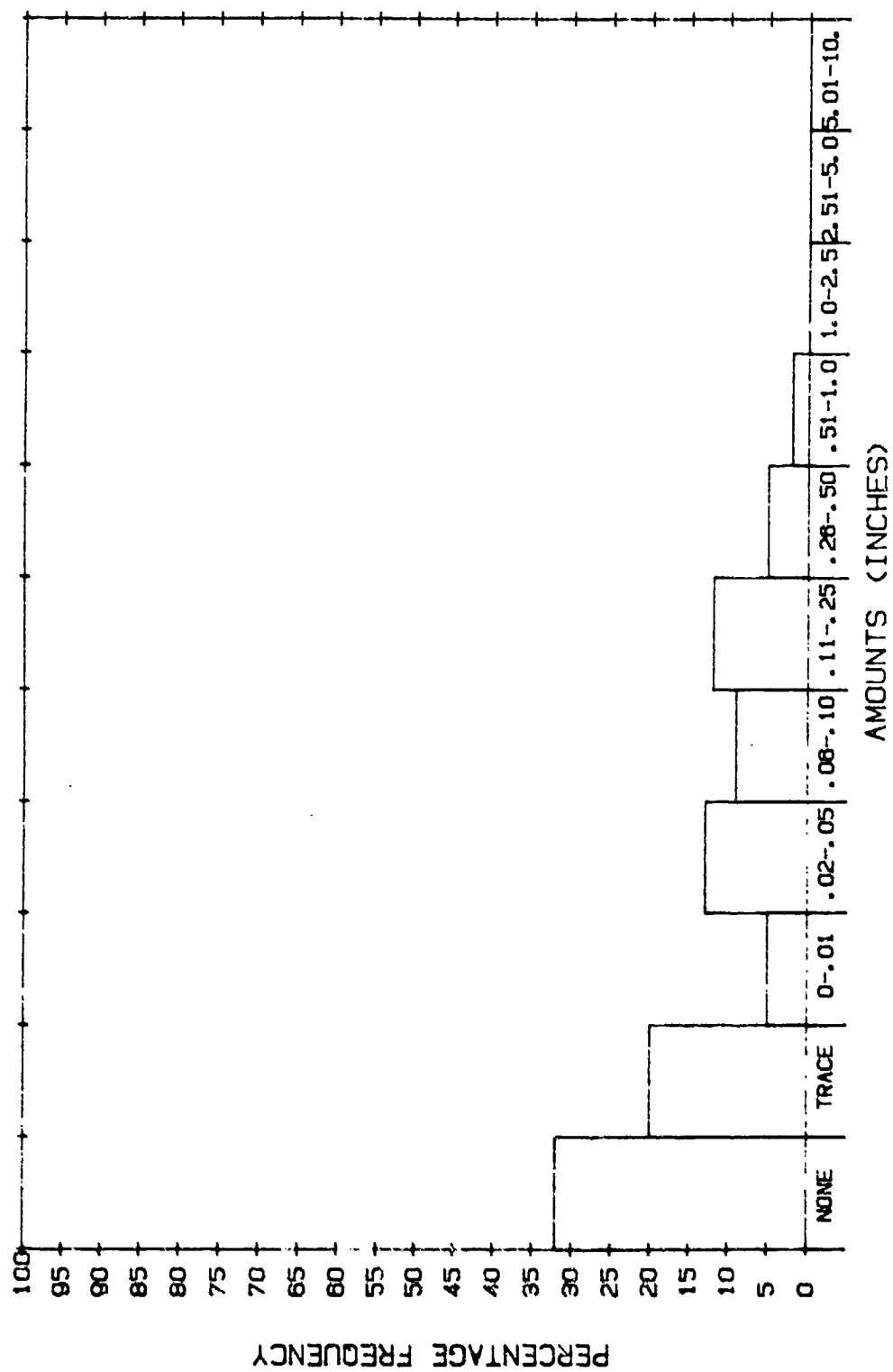


Figure A-105. Daily Amounts of Precipitation, Mean of German Airbases in February.

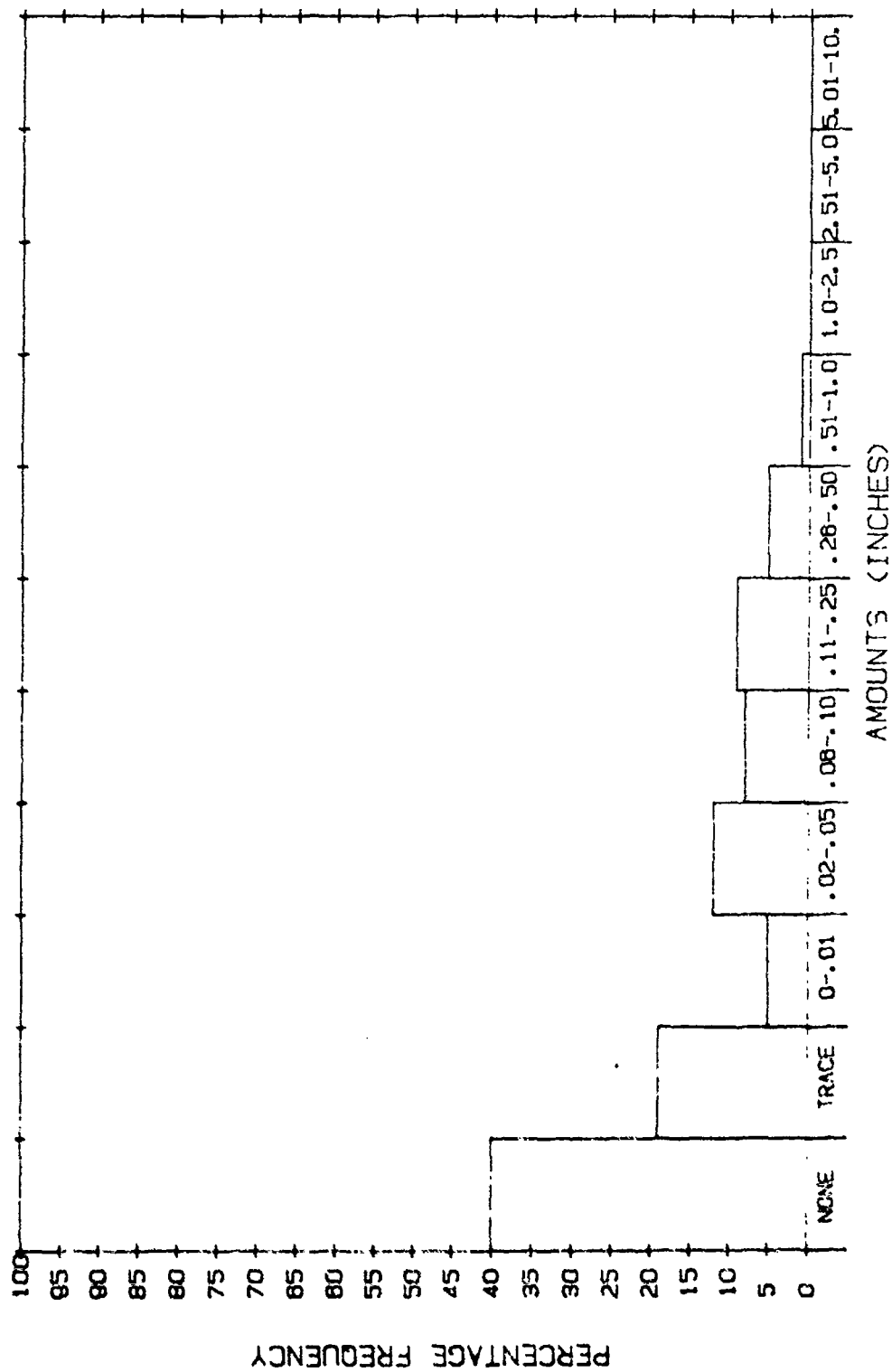


Figure A-106. Daily Amounts of Precipitation, Mean of German Airbases in March.

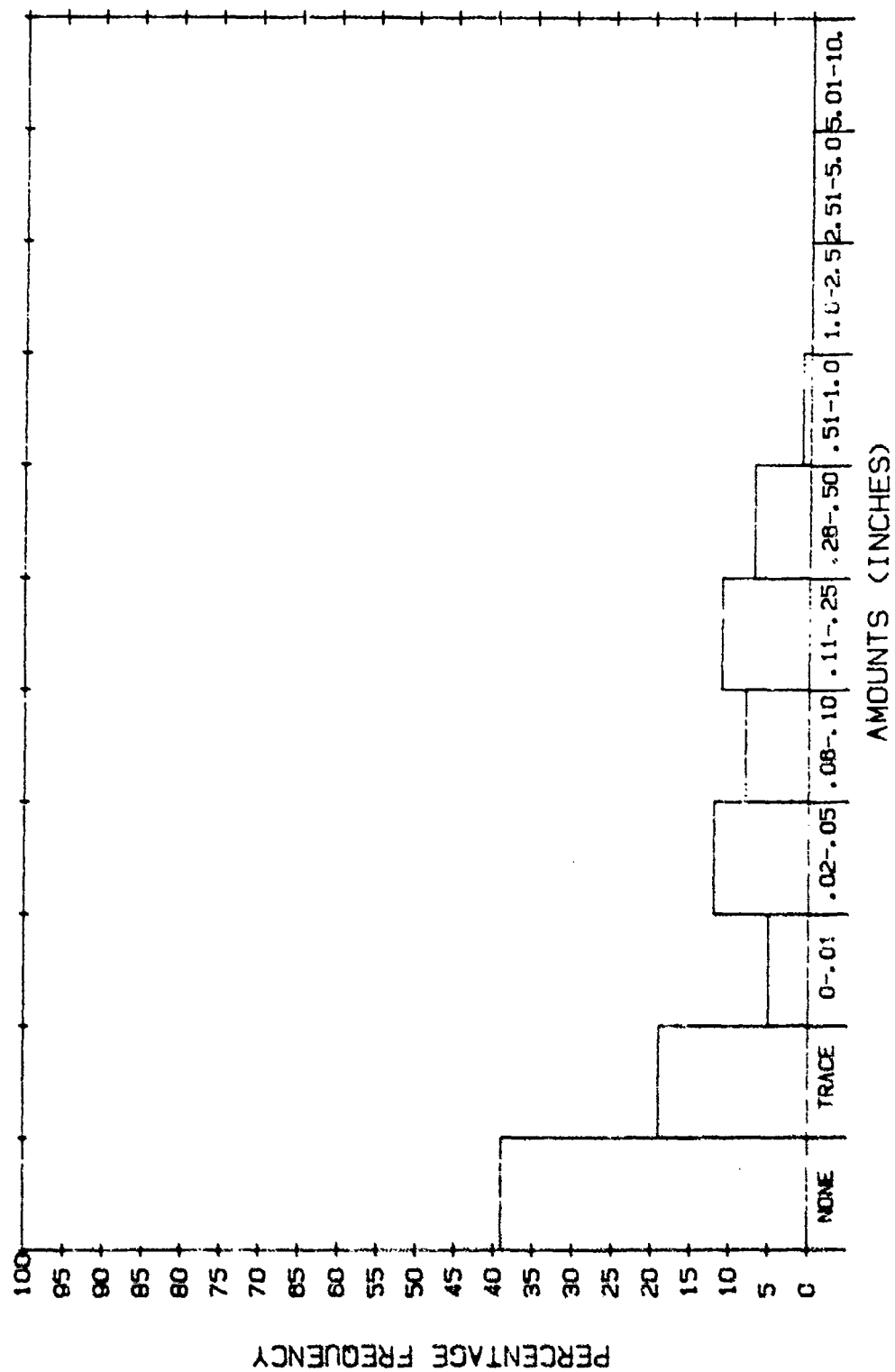


Figure A-107. Daily Amounts of Precipitation, Mean of German Airbases in April.

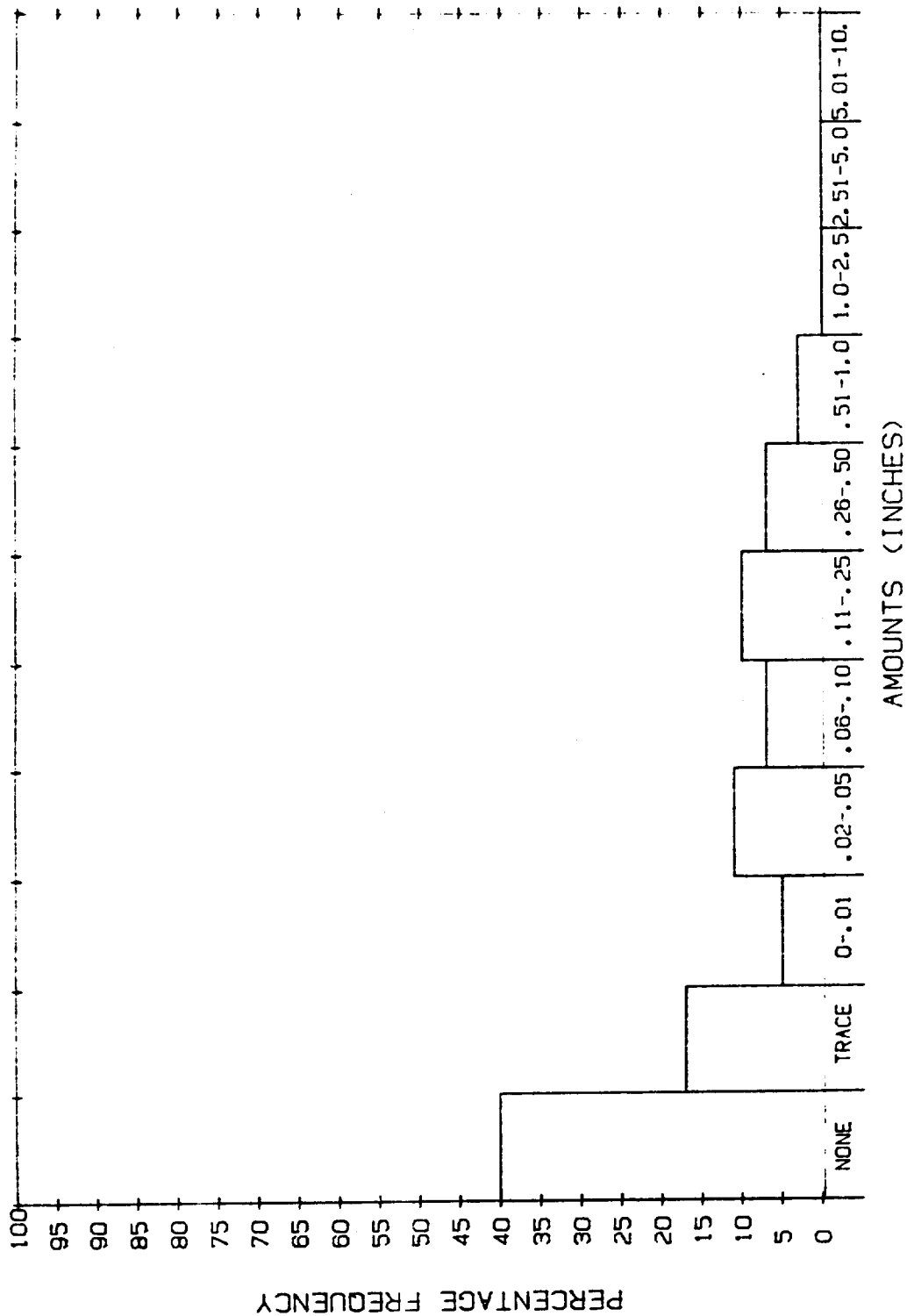


Figure A-108. Daily Amounts of Precipitation, Mean of German Airbases in May.

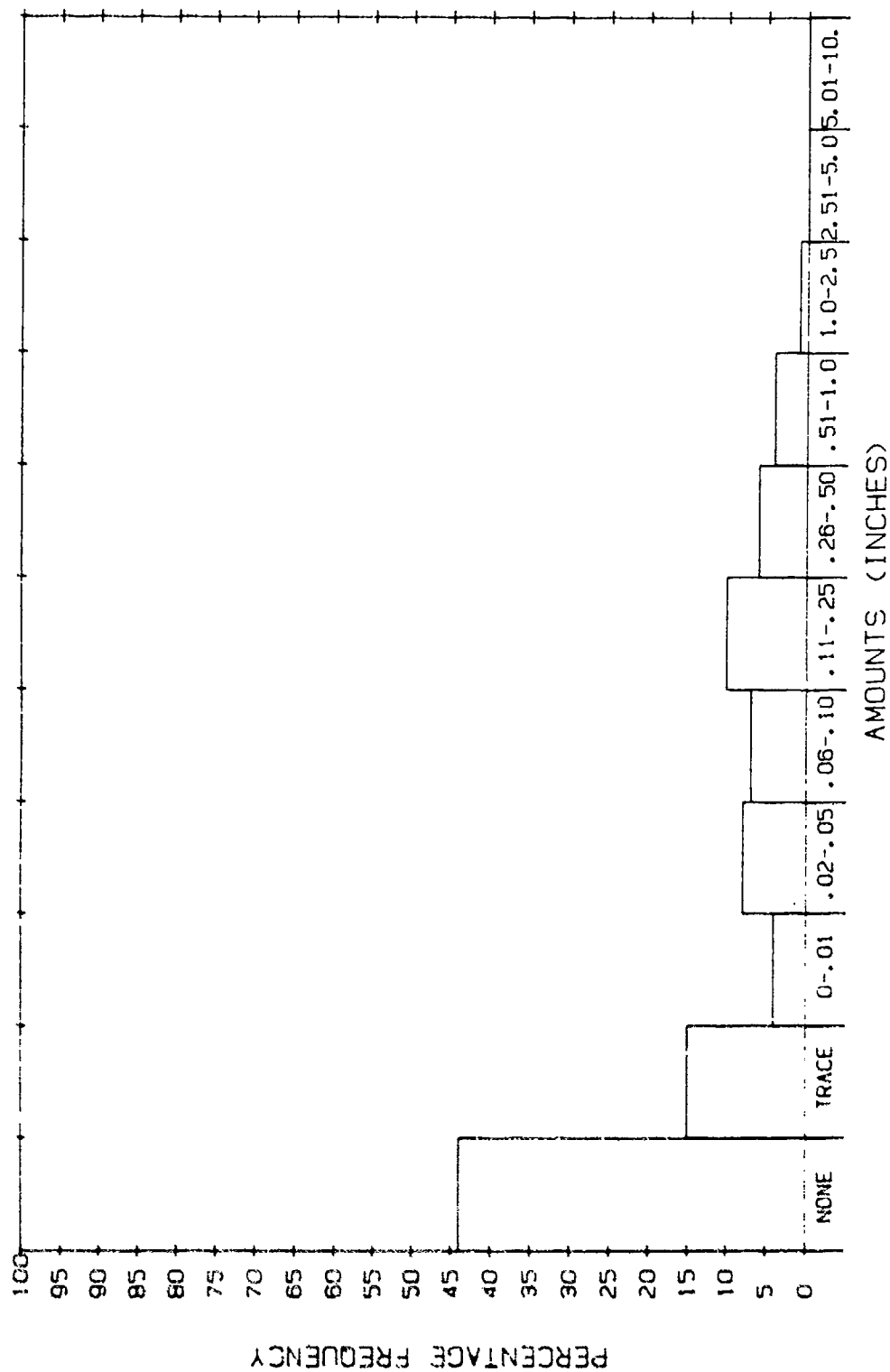


Figure A-109. Daily Amounts of Precipitation, Mean of German Airbases in June.

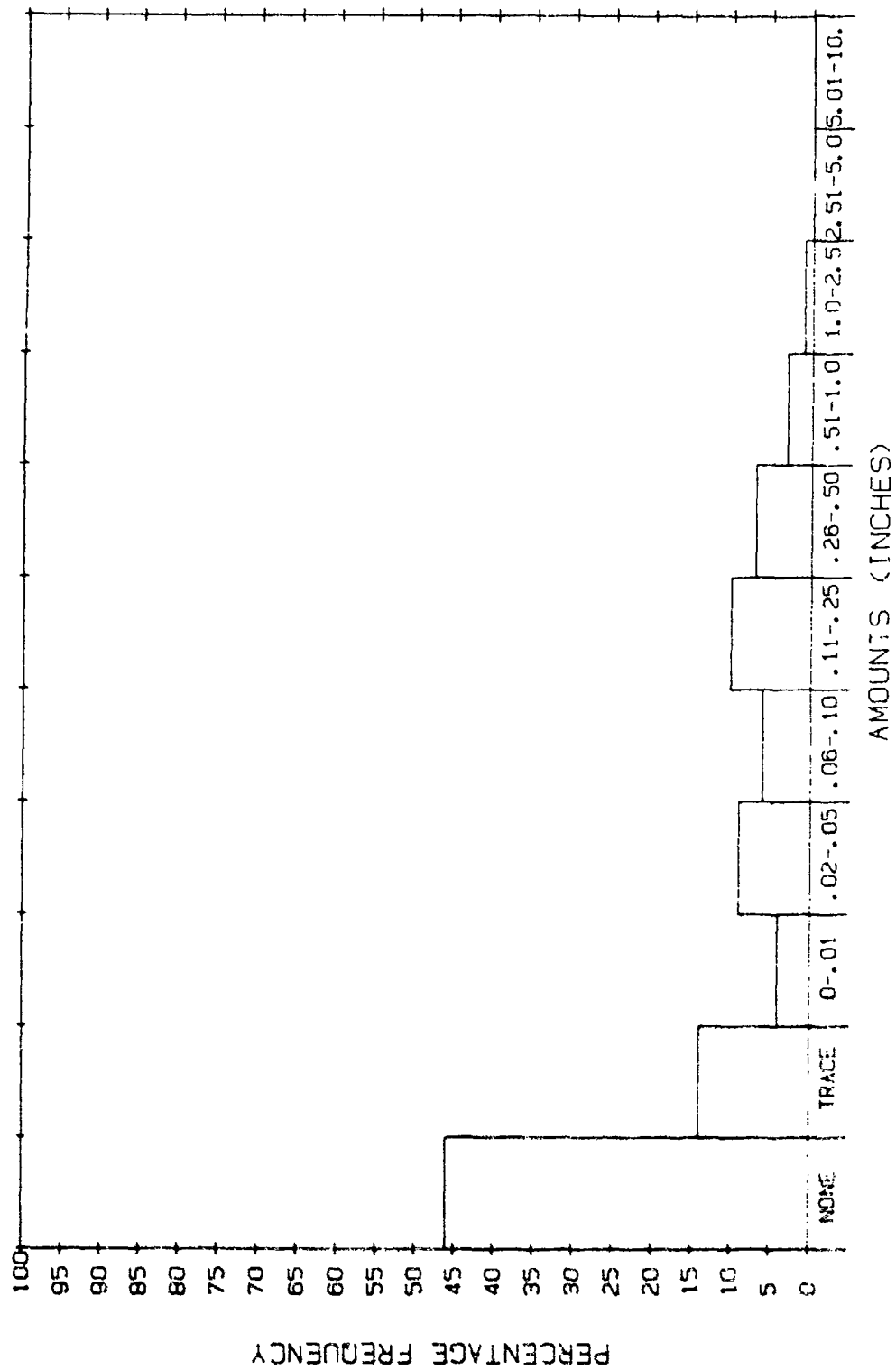


Figure A-110. Daily Amounts of Precipitation, Mean of German Airbases in July.

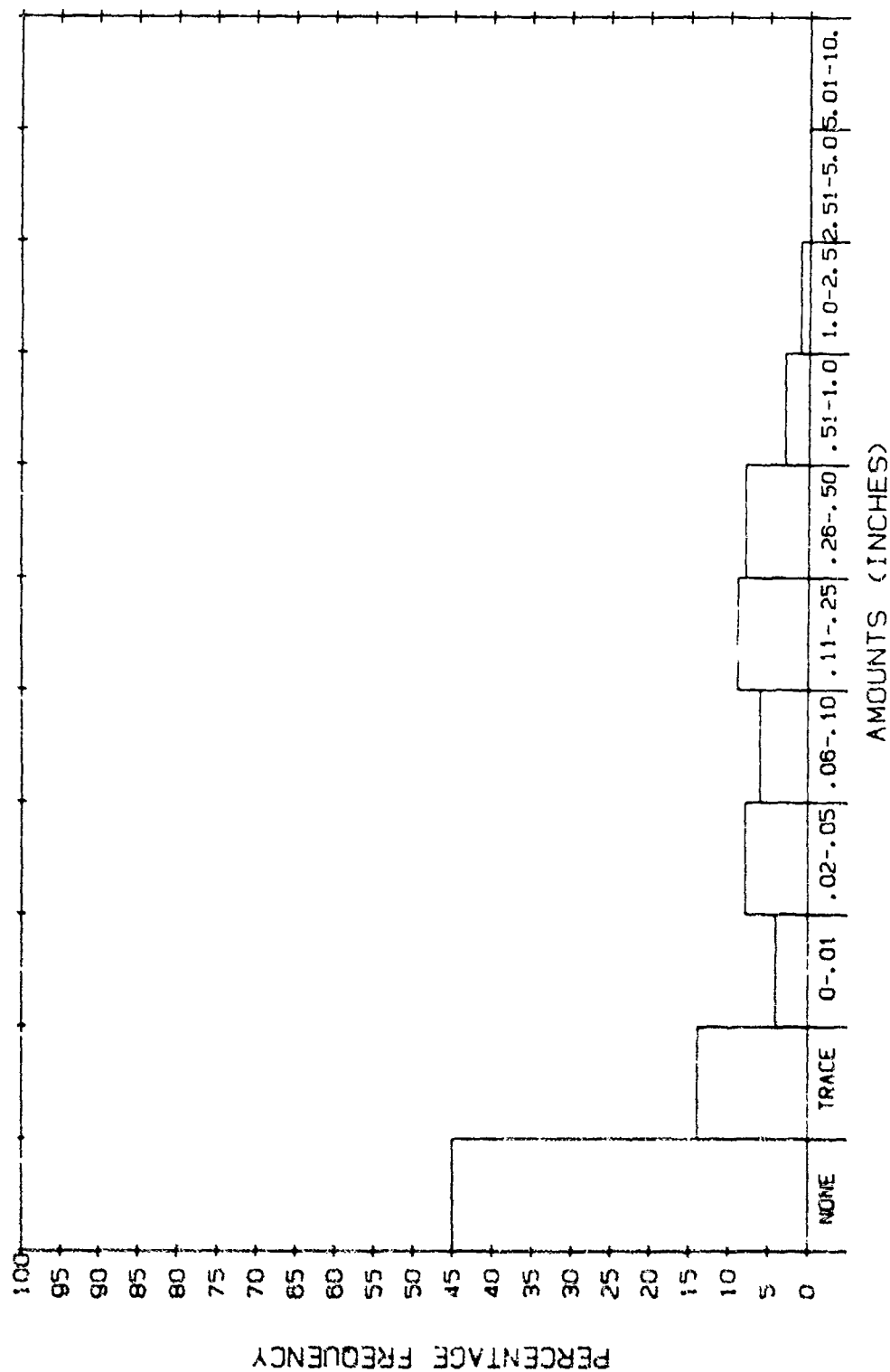


Figure A-111. Daily Amounts of Precipitation, Mean of German Airbases in August.

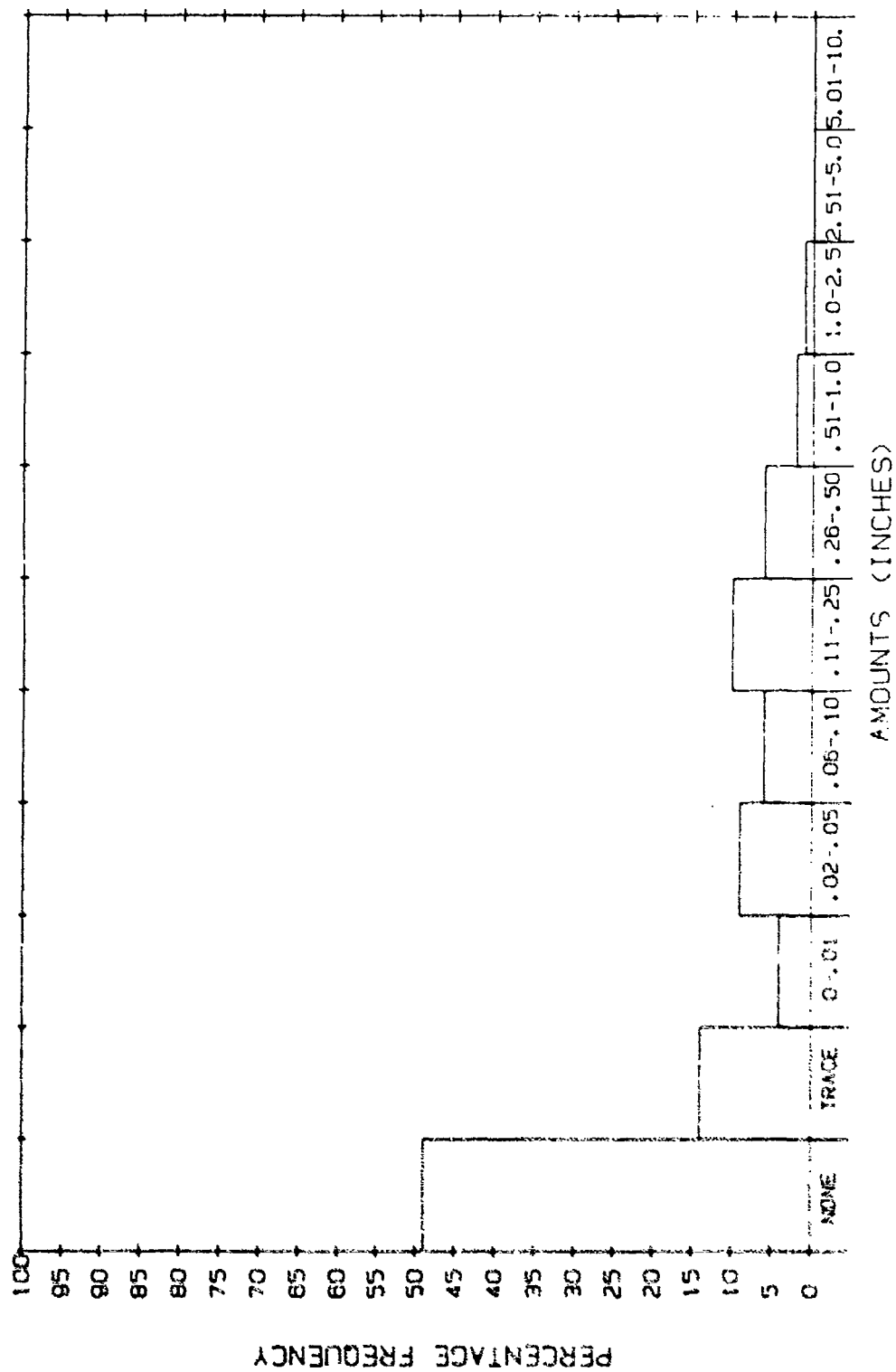


Figure A-112. Daily Amounts of Precipitation, Mean of German Airbases in September.

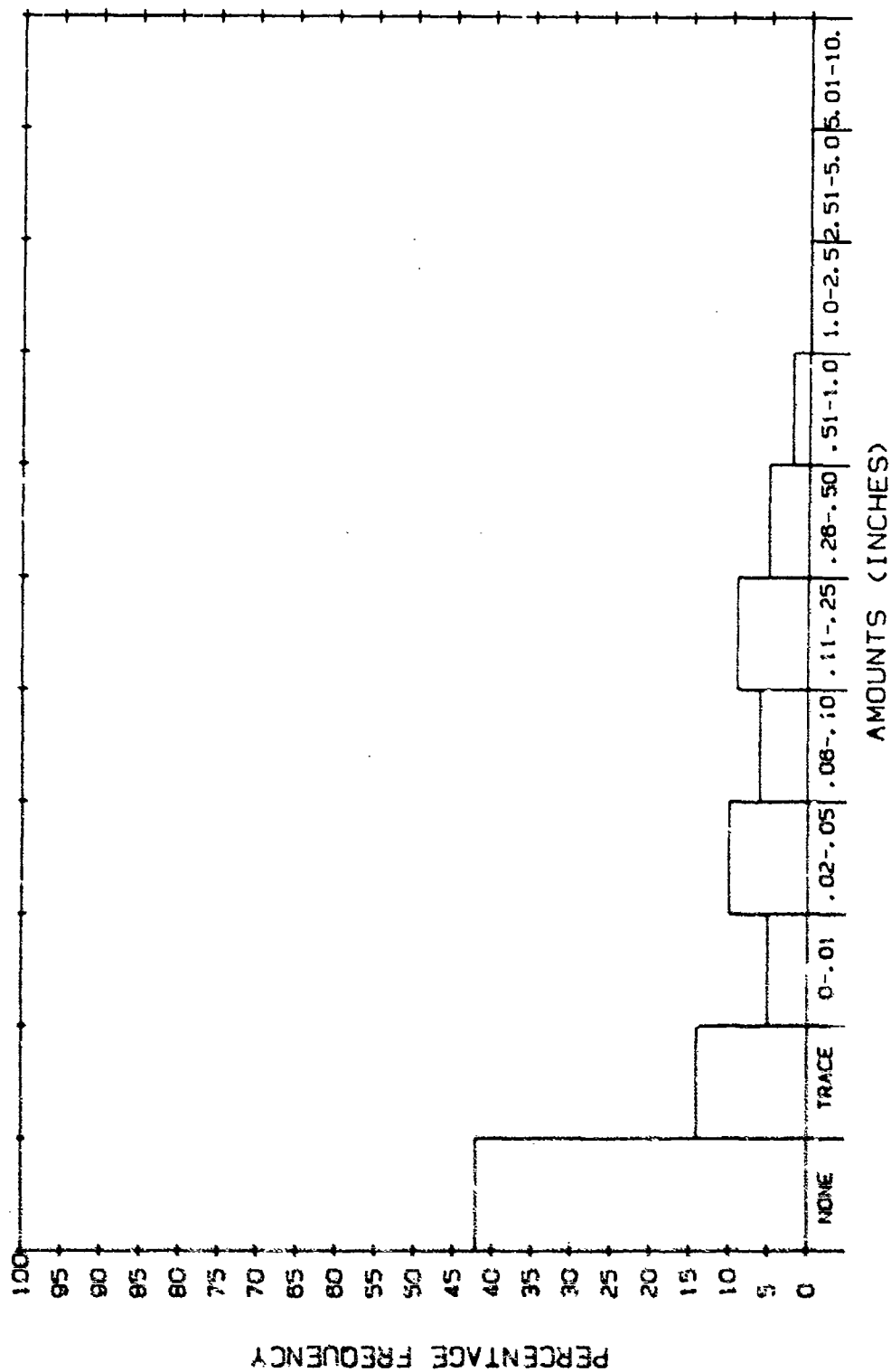


Figure A-113. Daily Amounts of Precipitation, Mean of German Airbases in October.

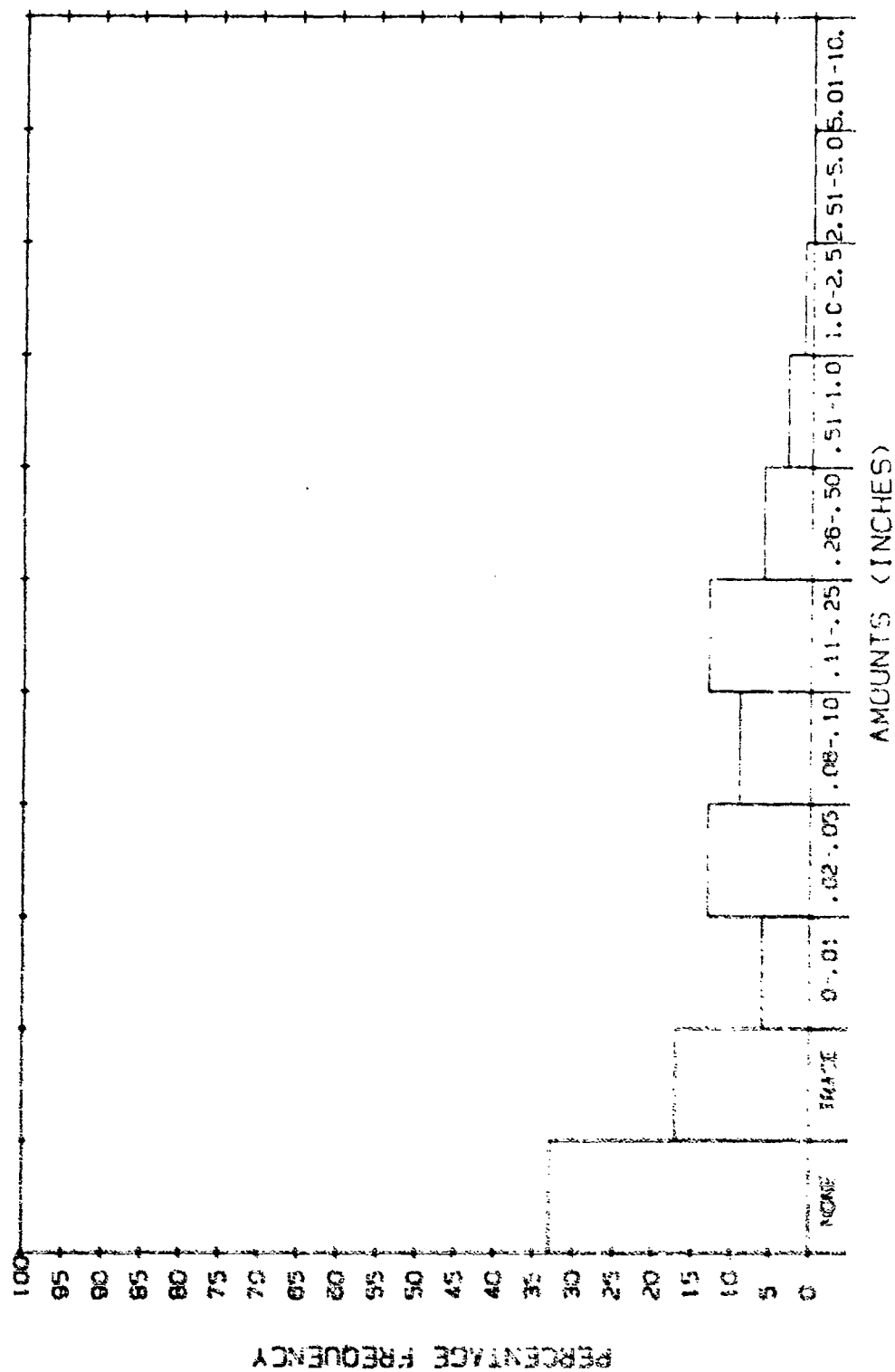


Figure A-114. Daily Amounts of Precipitation, Mean of German Airbases in November.

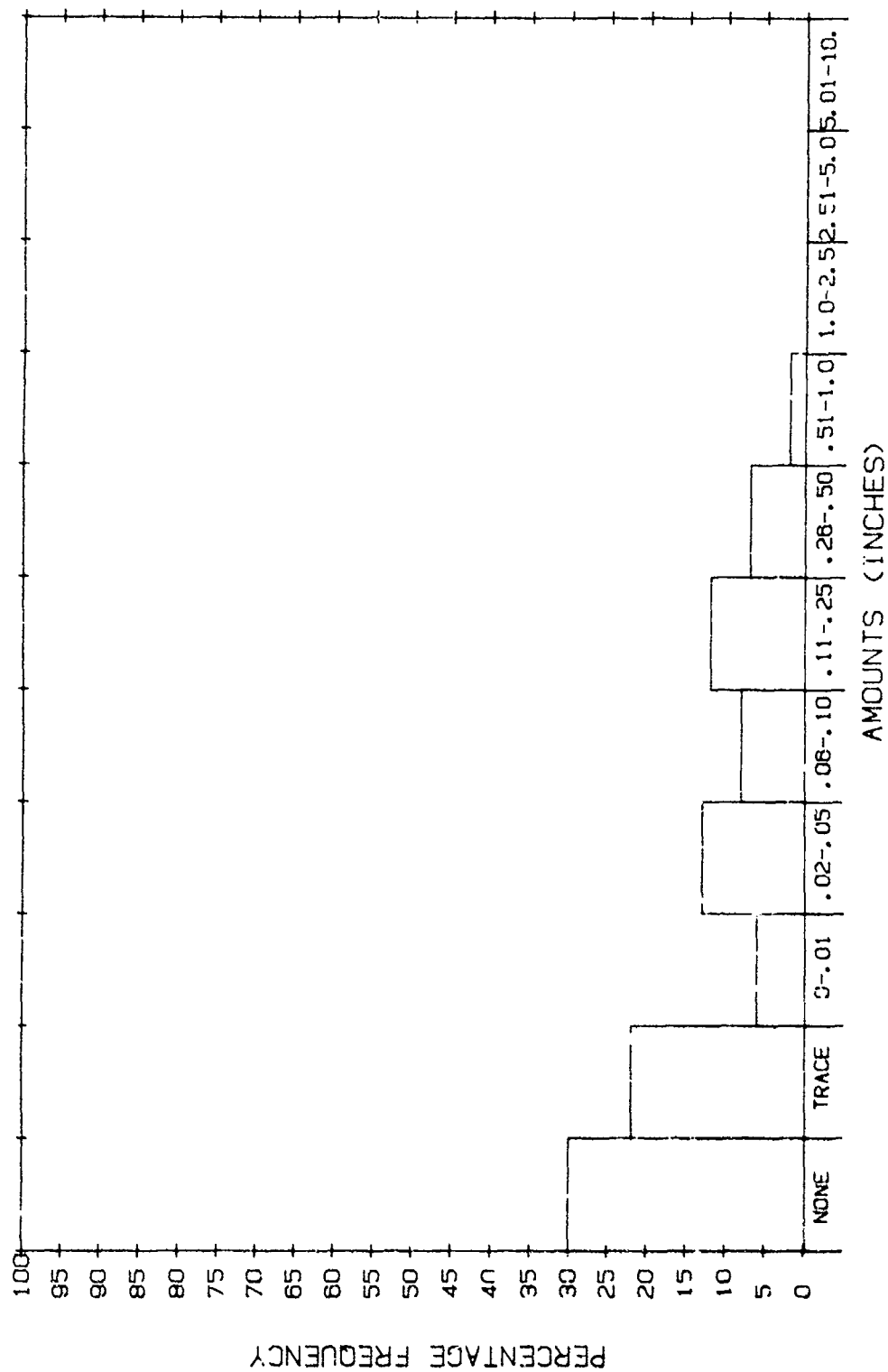


Figure A-115. Daily Amounts of Precipitation, Mean of German Airbases in December.

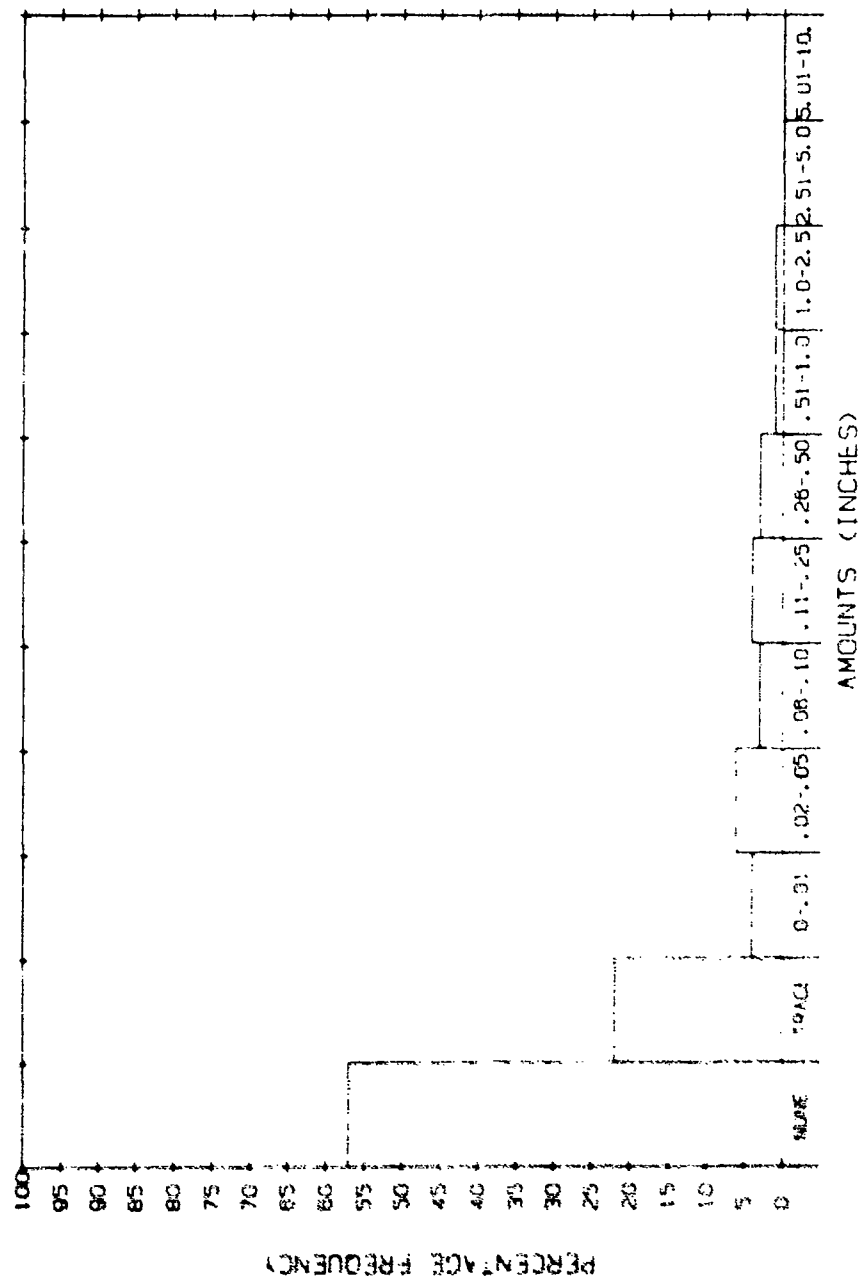


Figure A-116. Daily Amounts of Precipitation, Osan AFB, Korea in January.

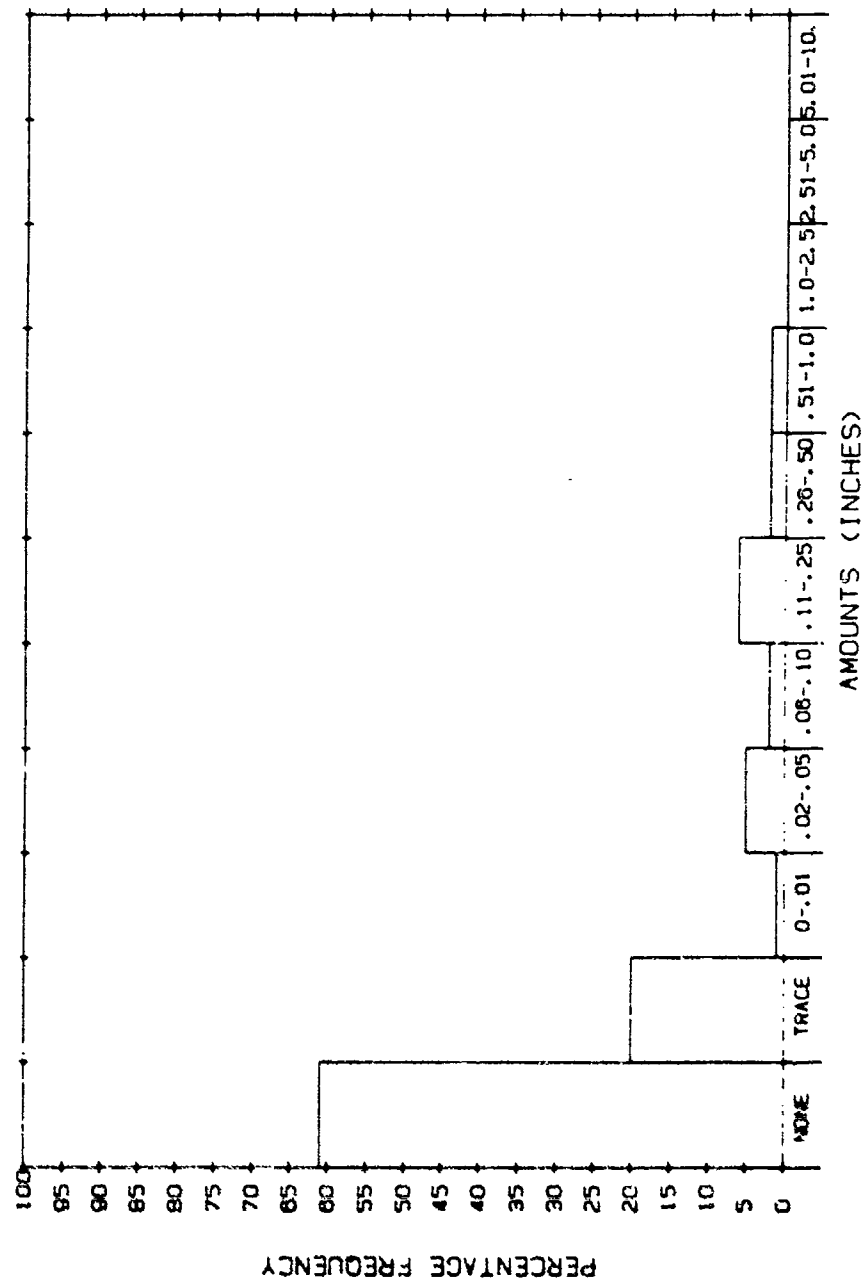


Figure A-117. Daily Amounts of Precipitation, Osan AFB, Korea in February.

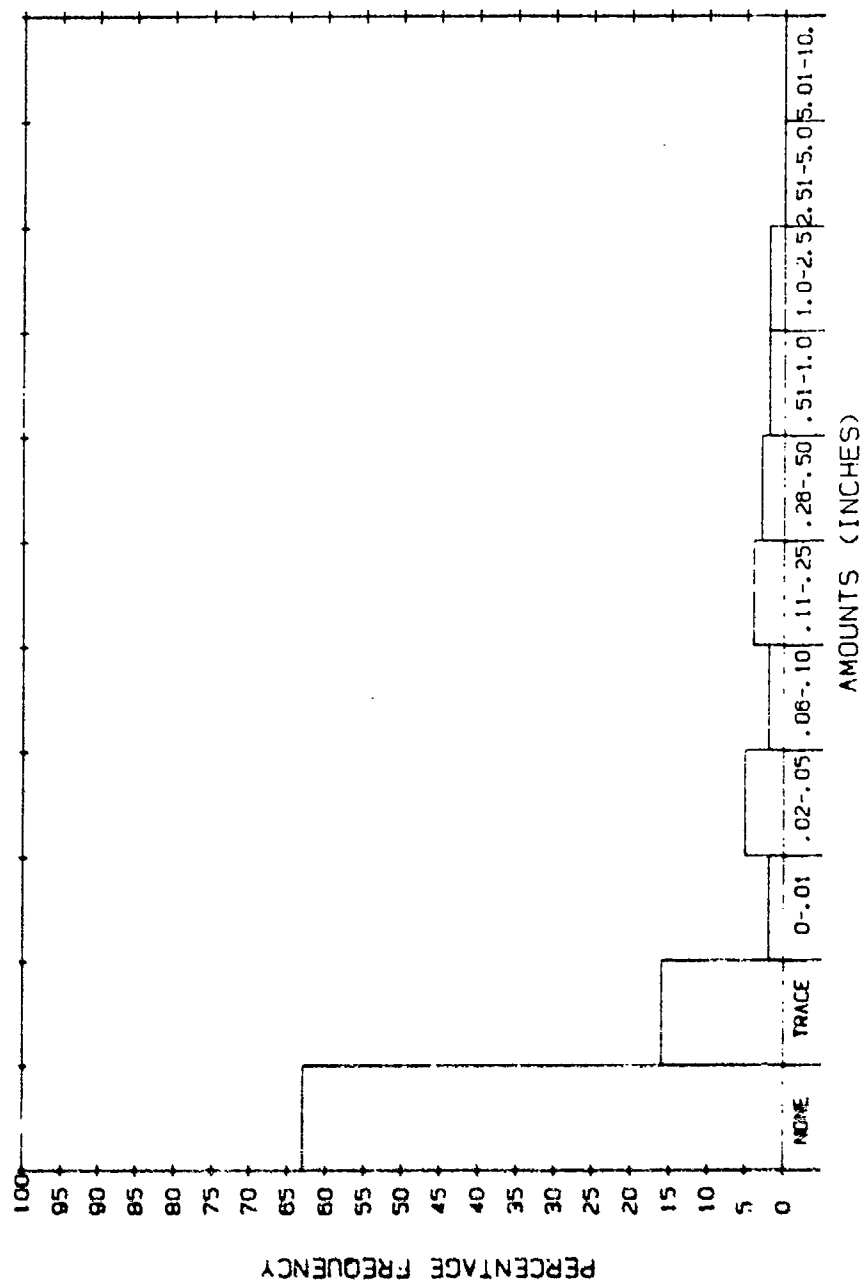


Figure A-118. Daily Amounts of Precipitation, Osan AFB, Korea in March.

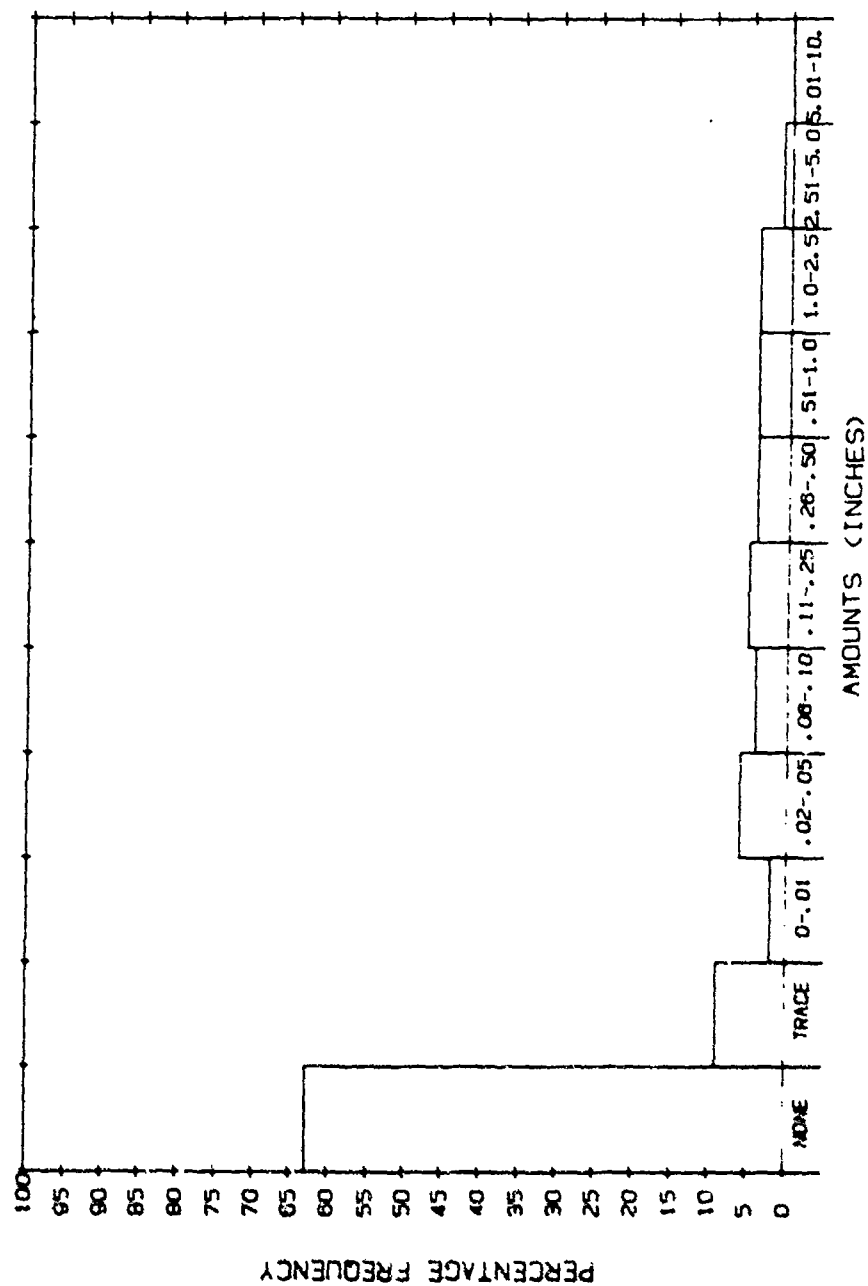


Figure A-119. Daily Amounts of Precipitation, Osan AFB, Korea in April.

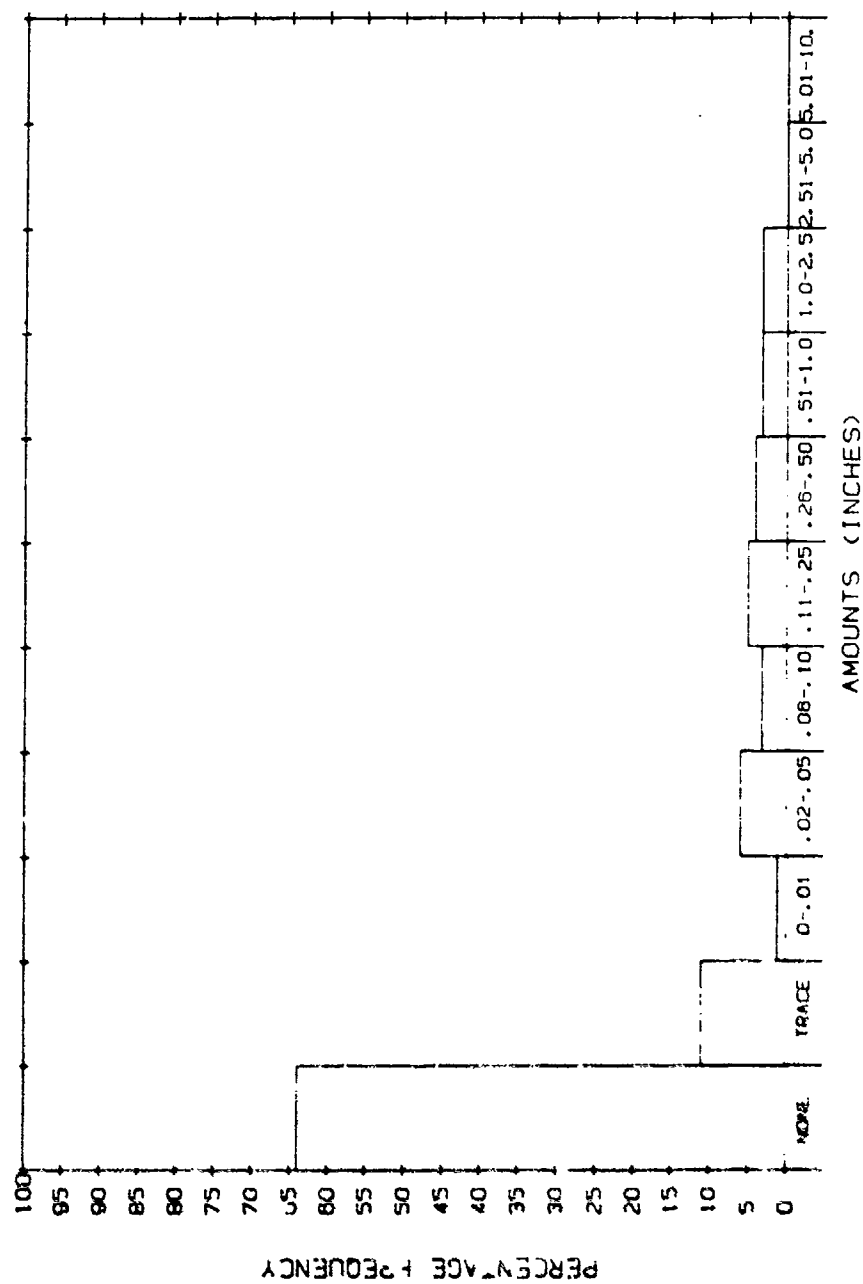


Figure A-120. Daily Amounts of Precipitation, Osan AFB, Korea in May.

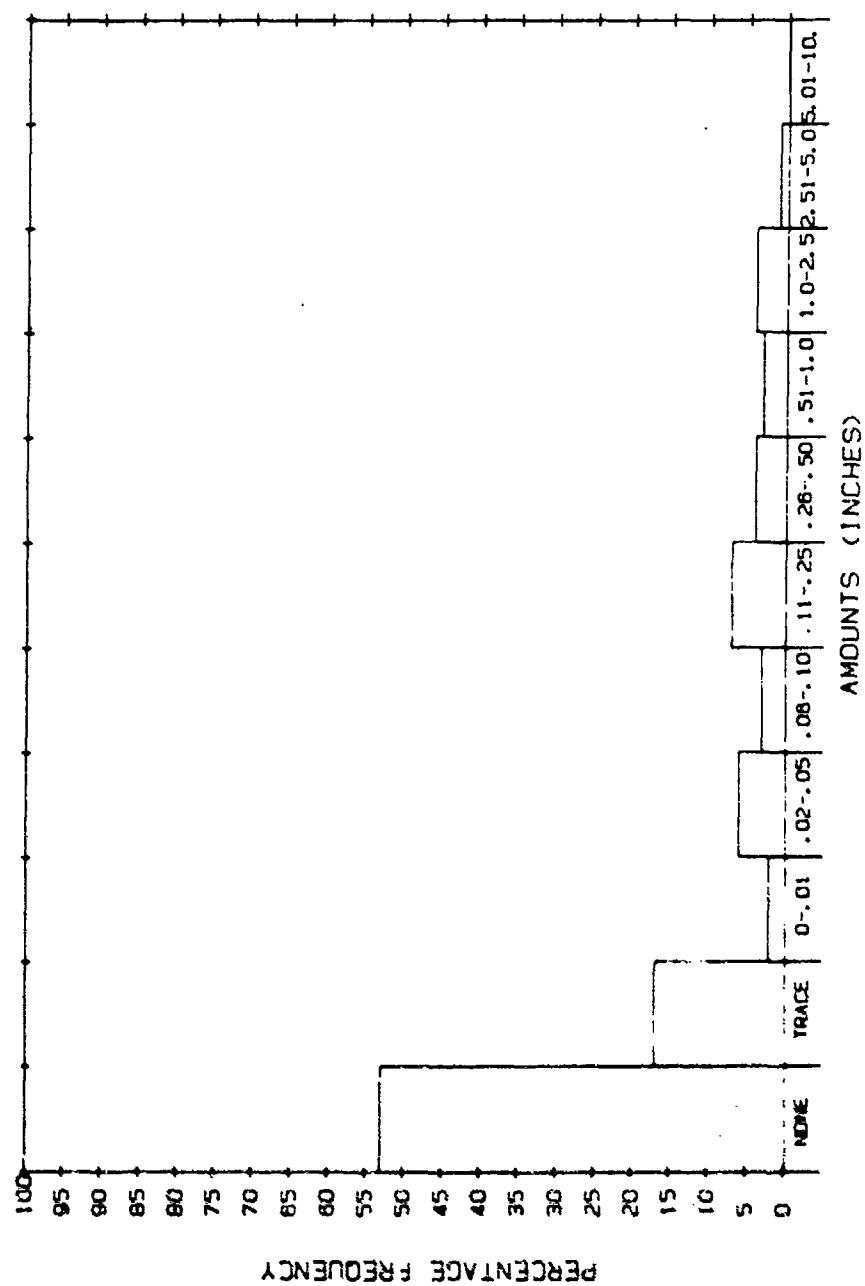


Figure A-121. Daily Amounts of Precipitation, Osan AFB, Korea in June.

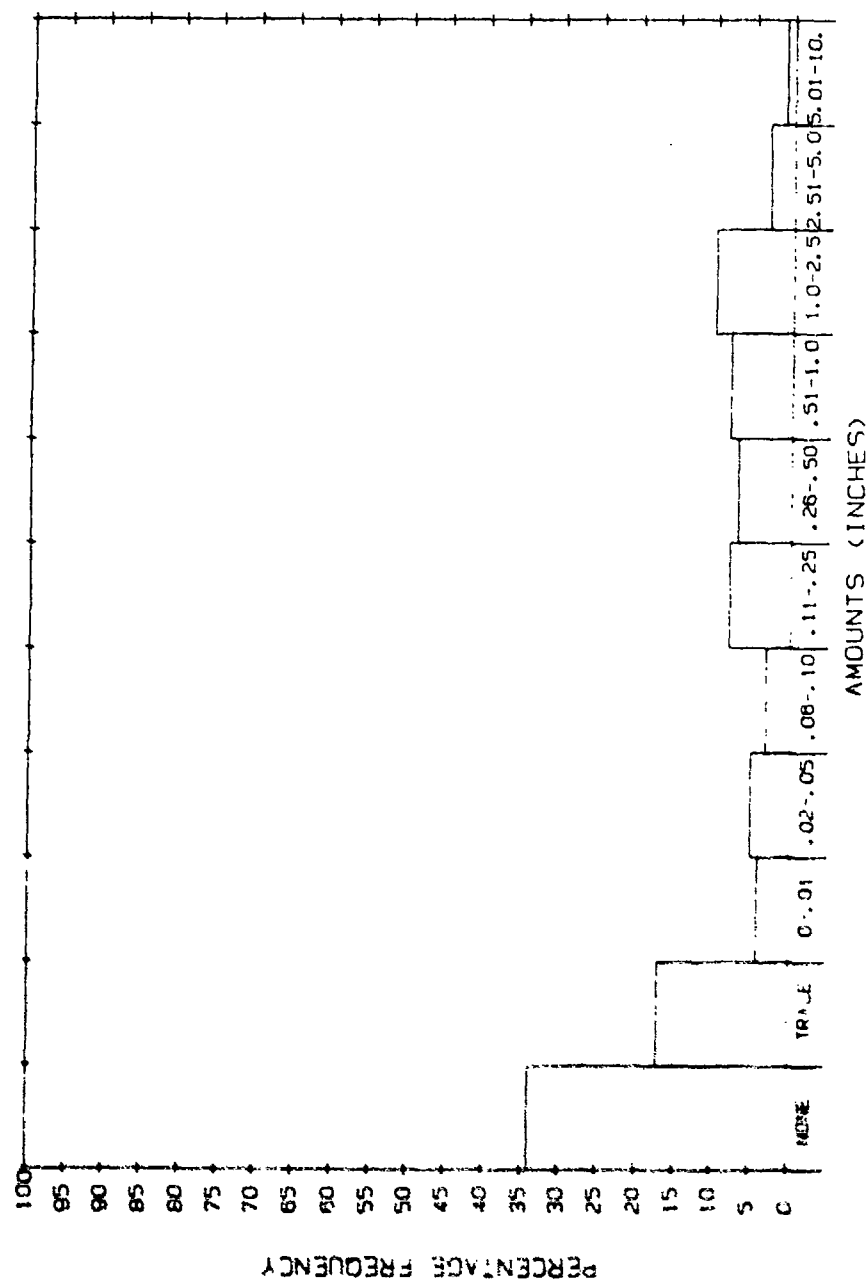


Figure A-122. Daily Amounts of Precipitation, Osan AFB, Korea in July.

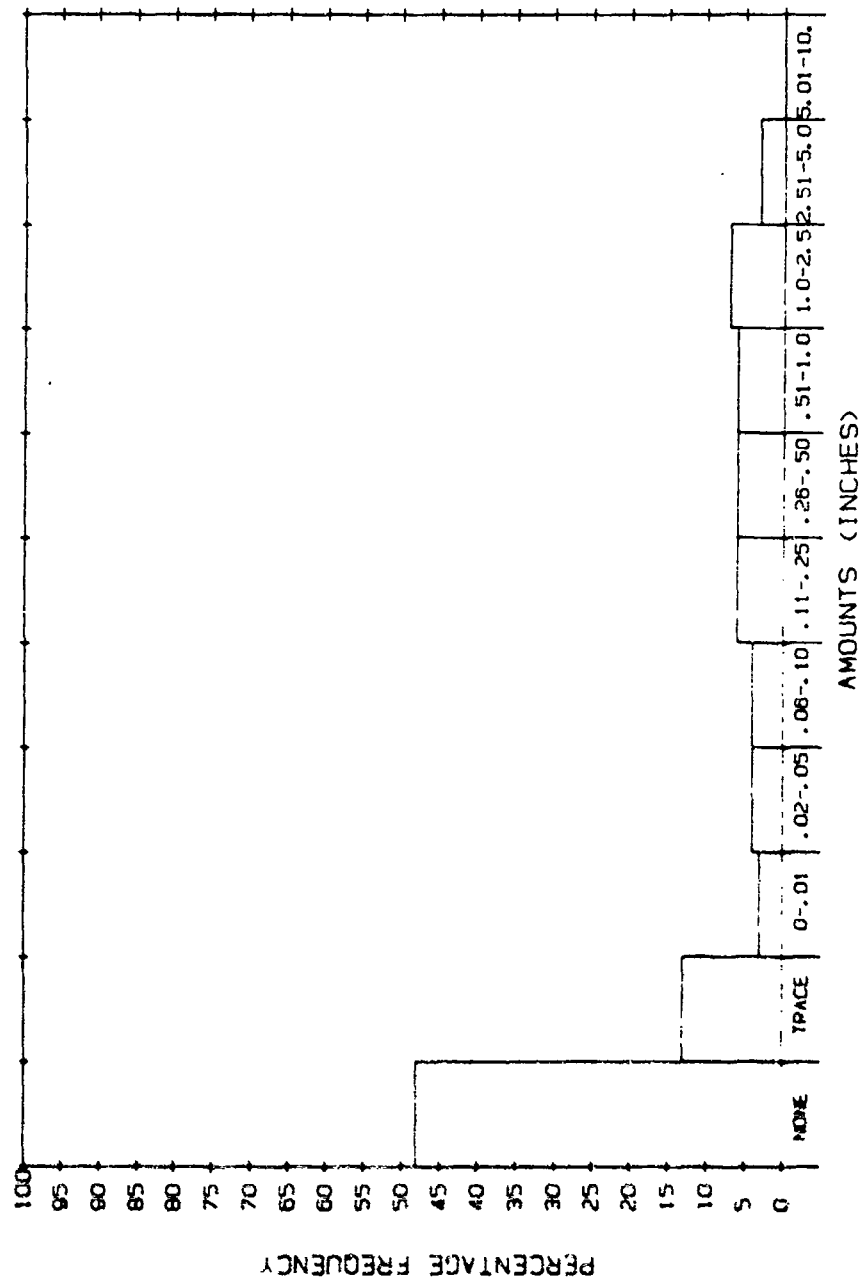


Figure A-123. Daily Amounts of Precipitation, Osan AFB, Korea in August.

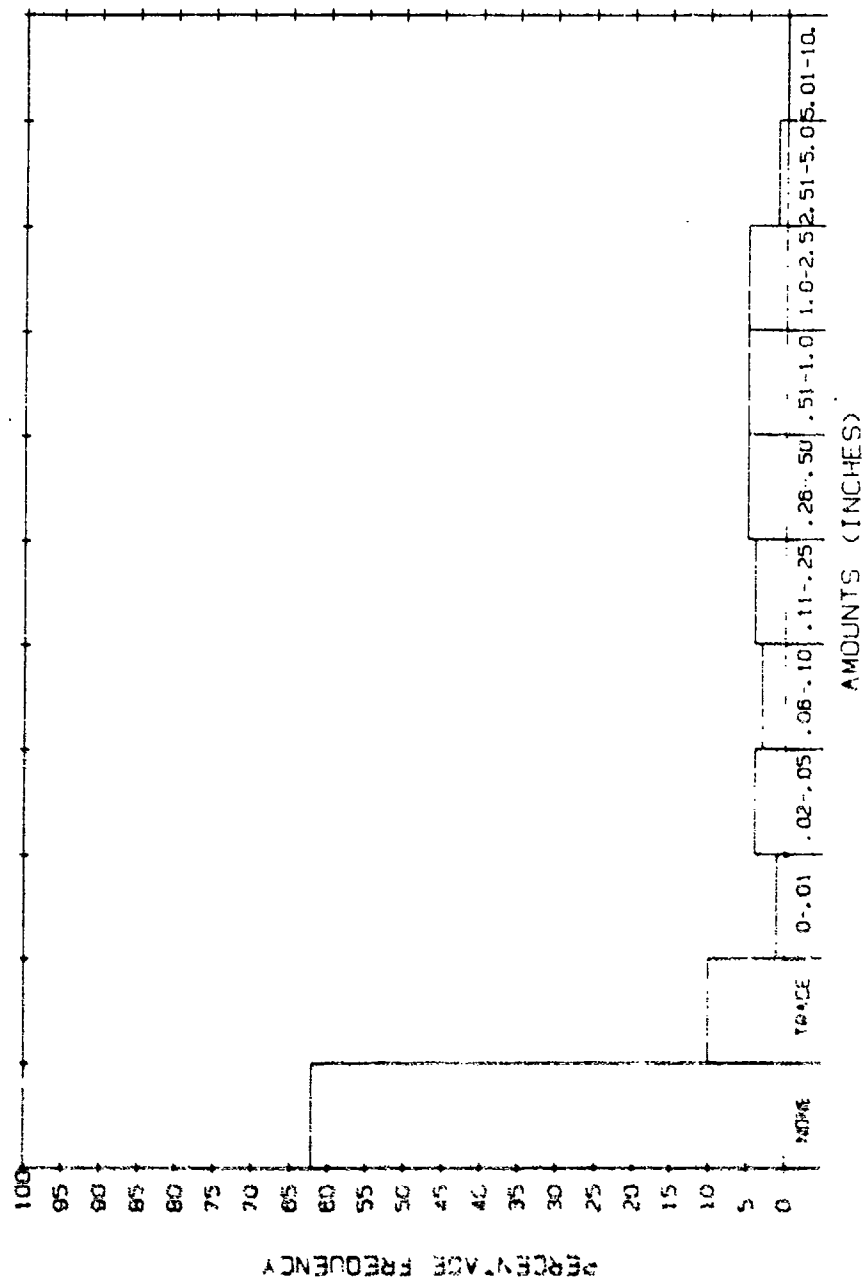


Figure A-124. Daily Amounts of Precipitation, Osan AFB, Korea in September.

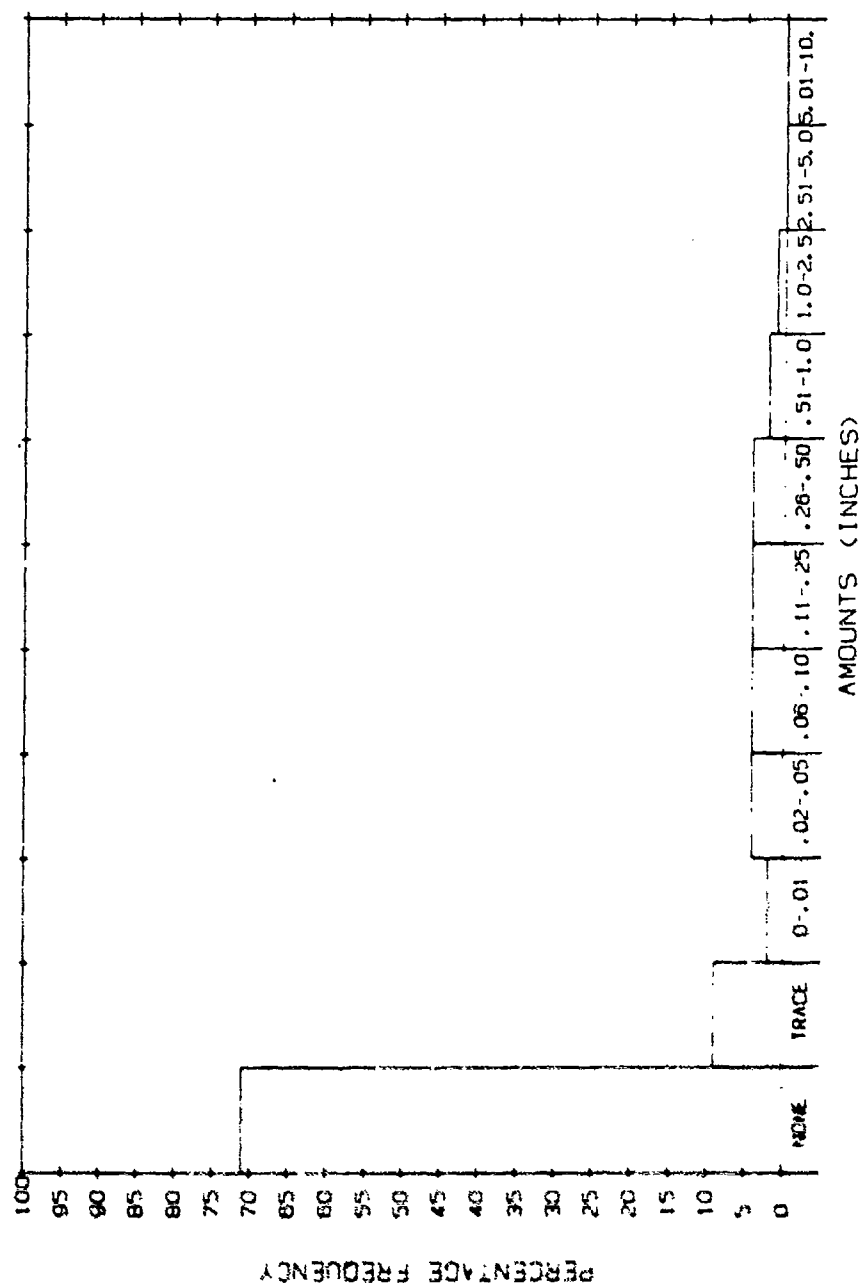


Figure A-125. Daily Amounts of Precipitation, Osan AFB, Korea in October.

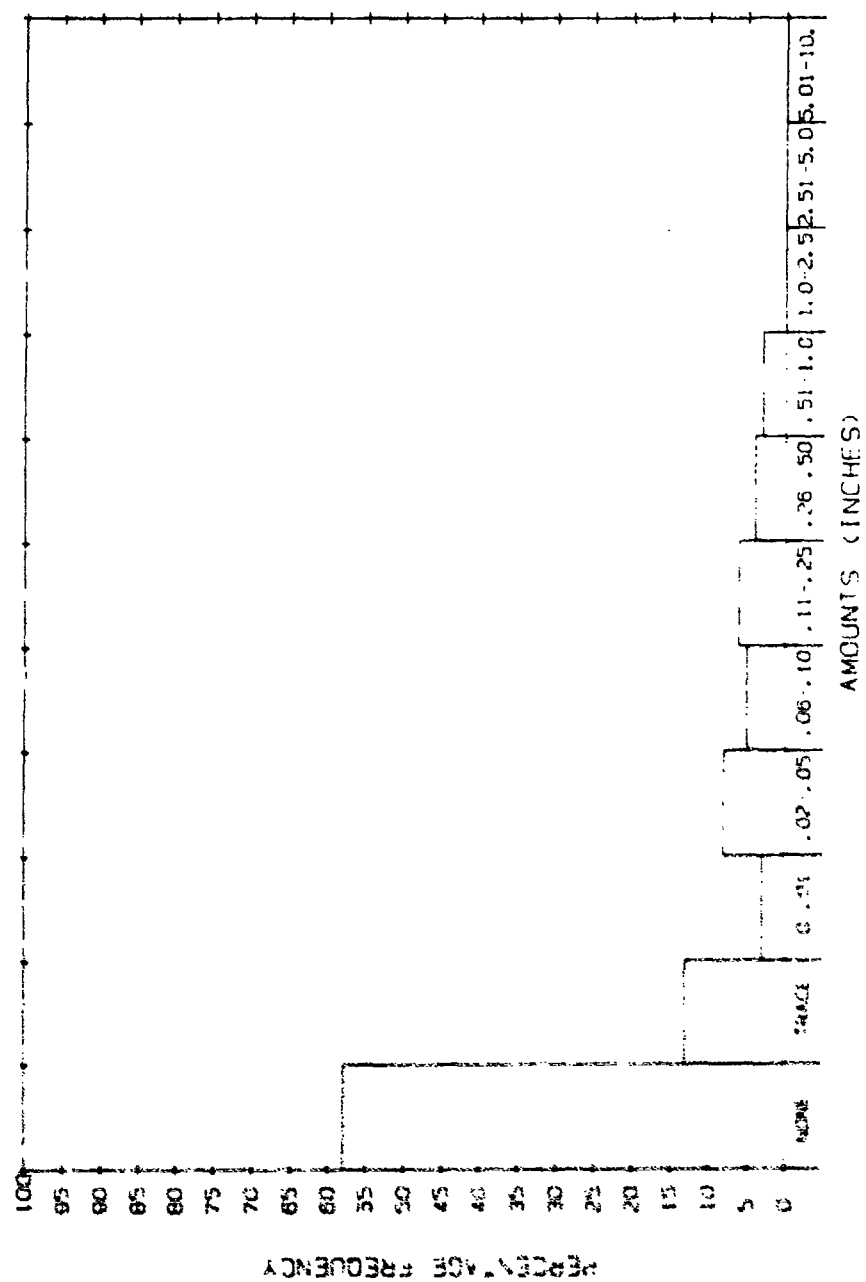


Figure A-126. Daily Amounts of Precipitation, Osan AFB, Korea in November.

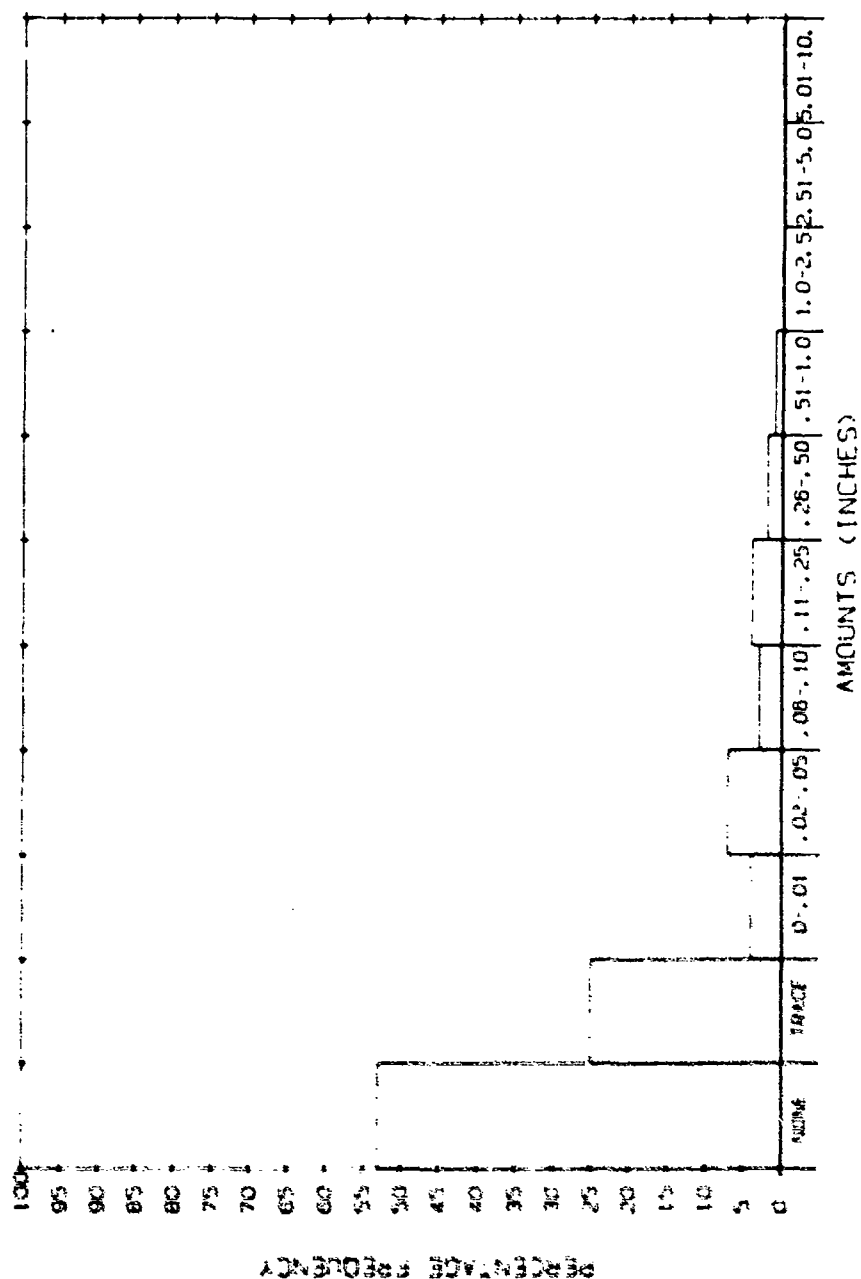


Figure A-127. Daily Amounts of Precipitation, Osan AFB, Korea in December.

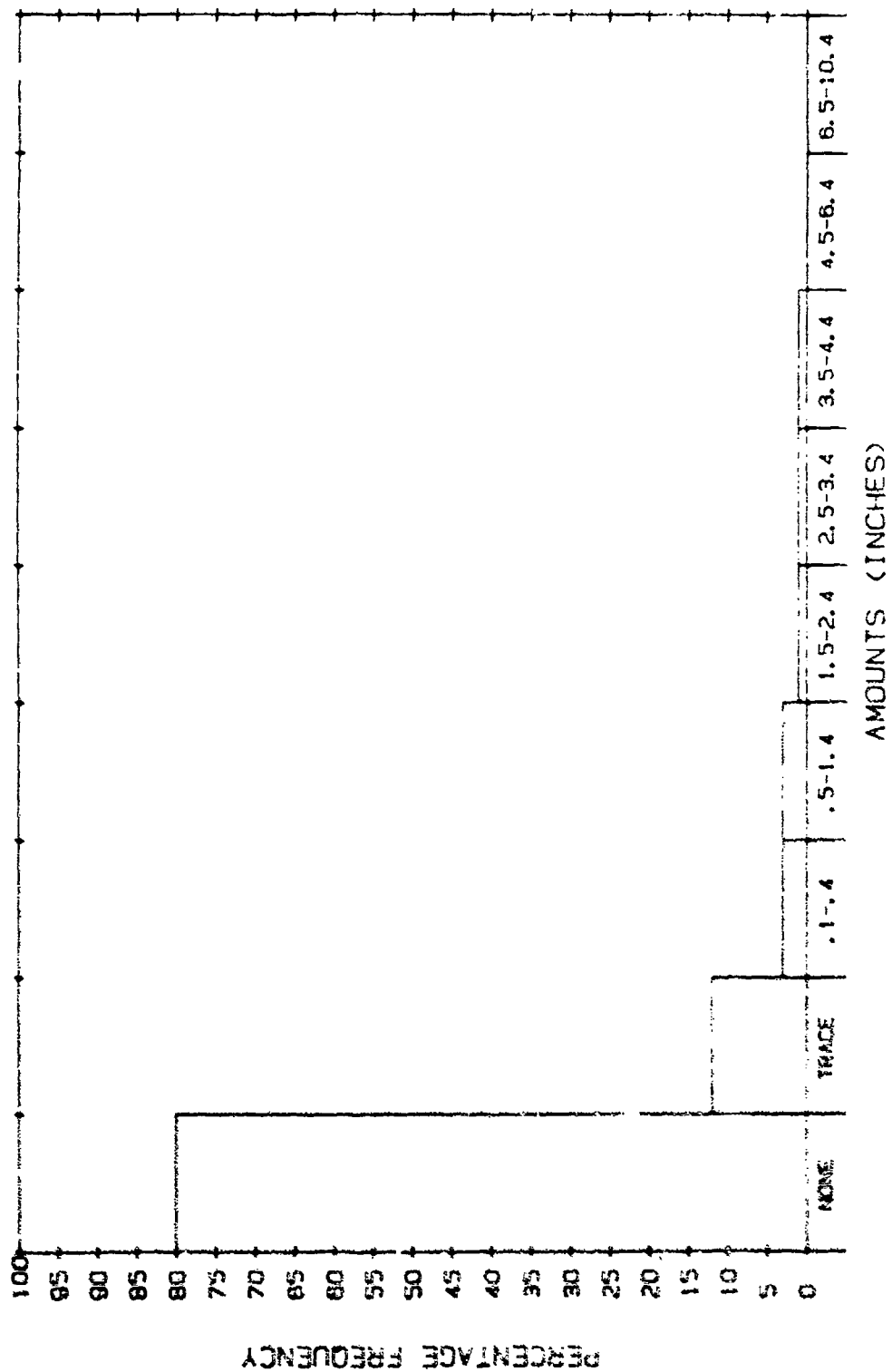


Figure A-128. Daily Amounts of Snowfall, Upper Heyford in January.

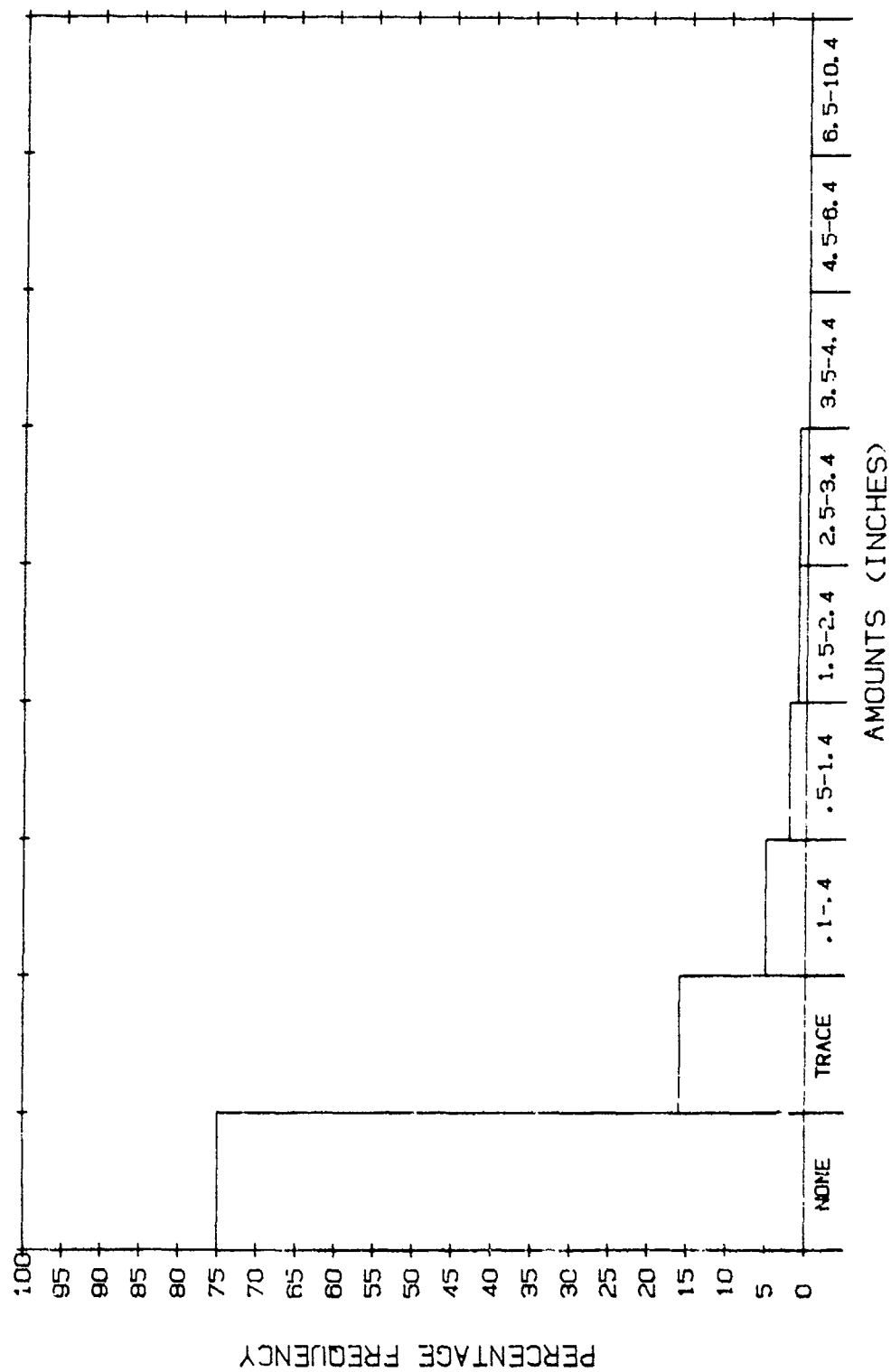


Figure A-129. Daily Amounts of Snowfall, Upper Heyford in February.

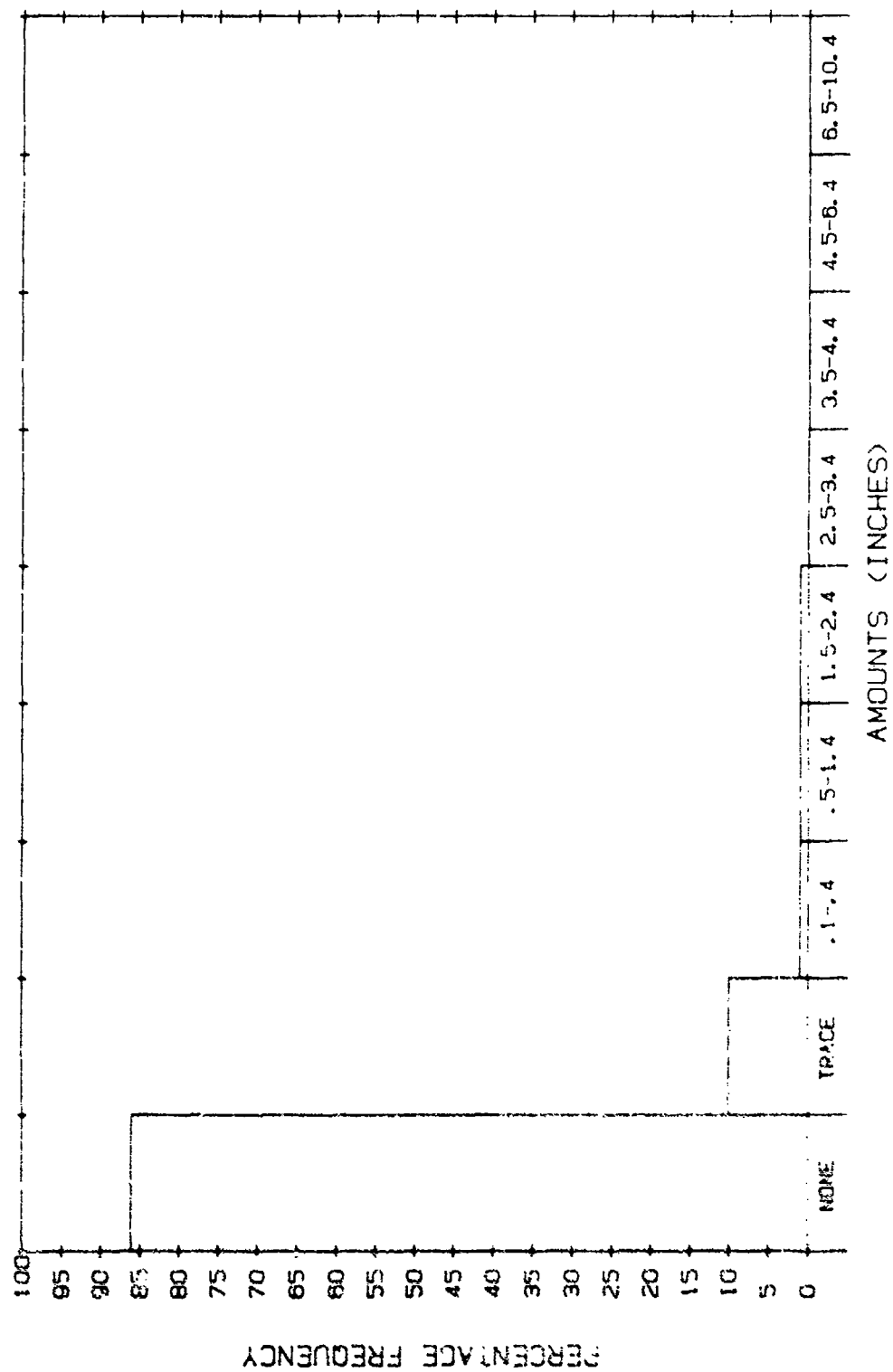


Figure A-130. Daily Amounts of Snowfall, Upper Heyford in March.

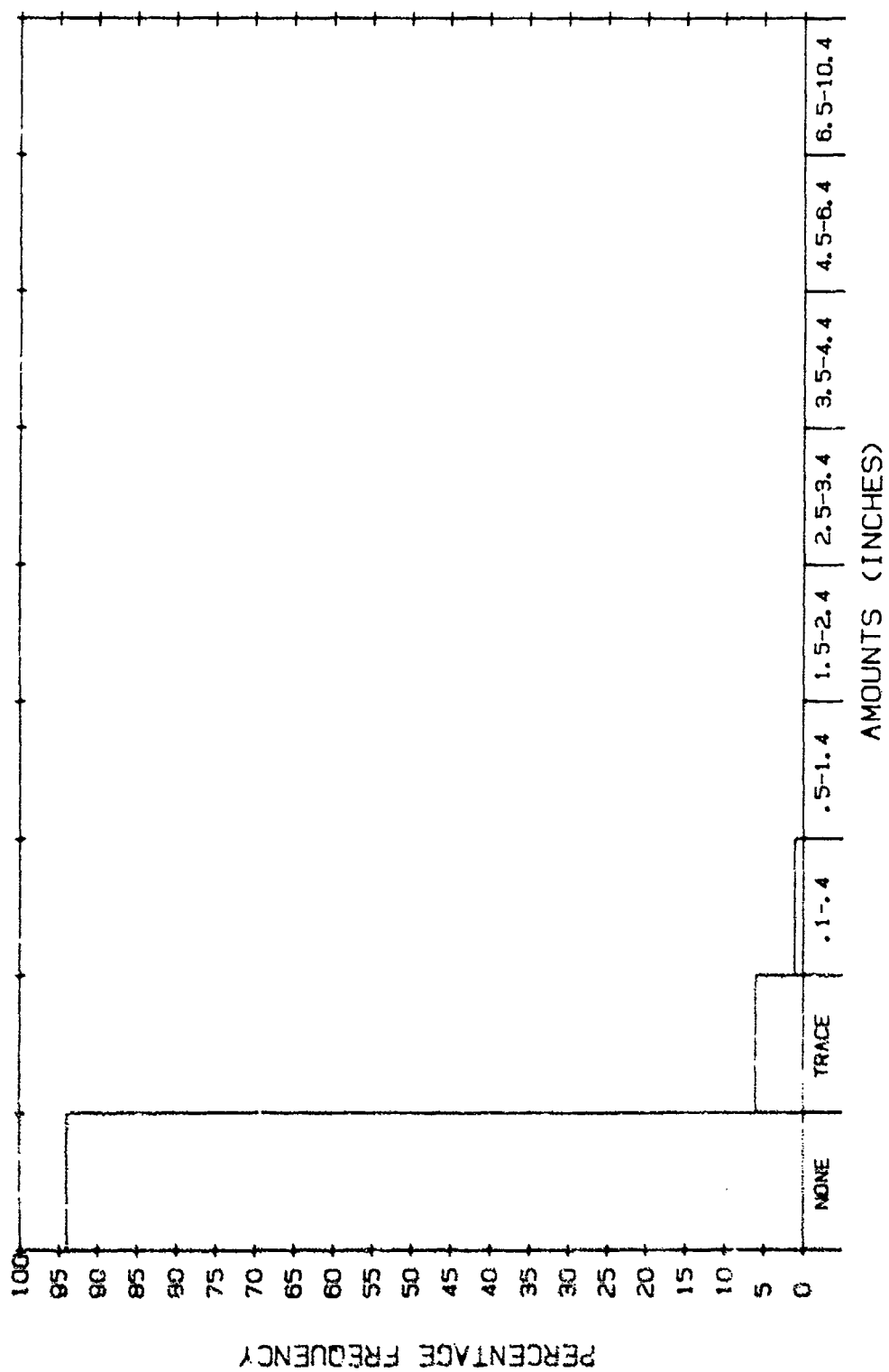


Figure A-131. Daily Amounts of Snowfall, Upper Heyford in April.

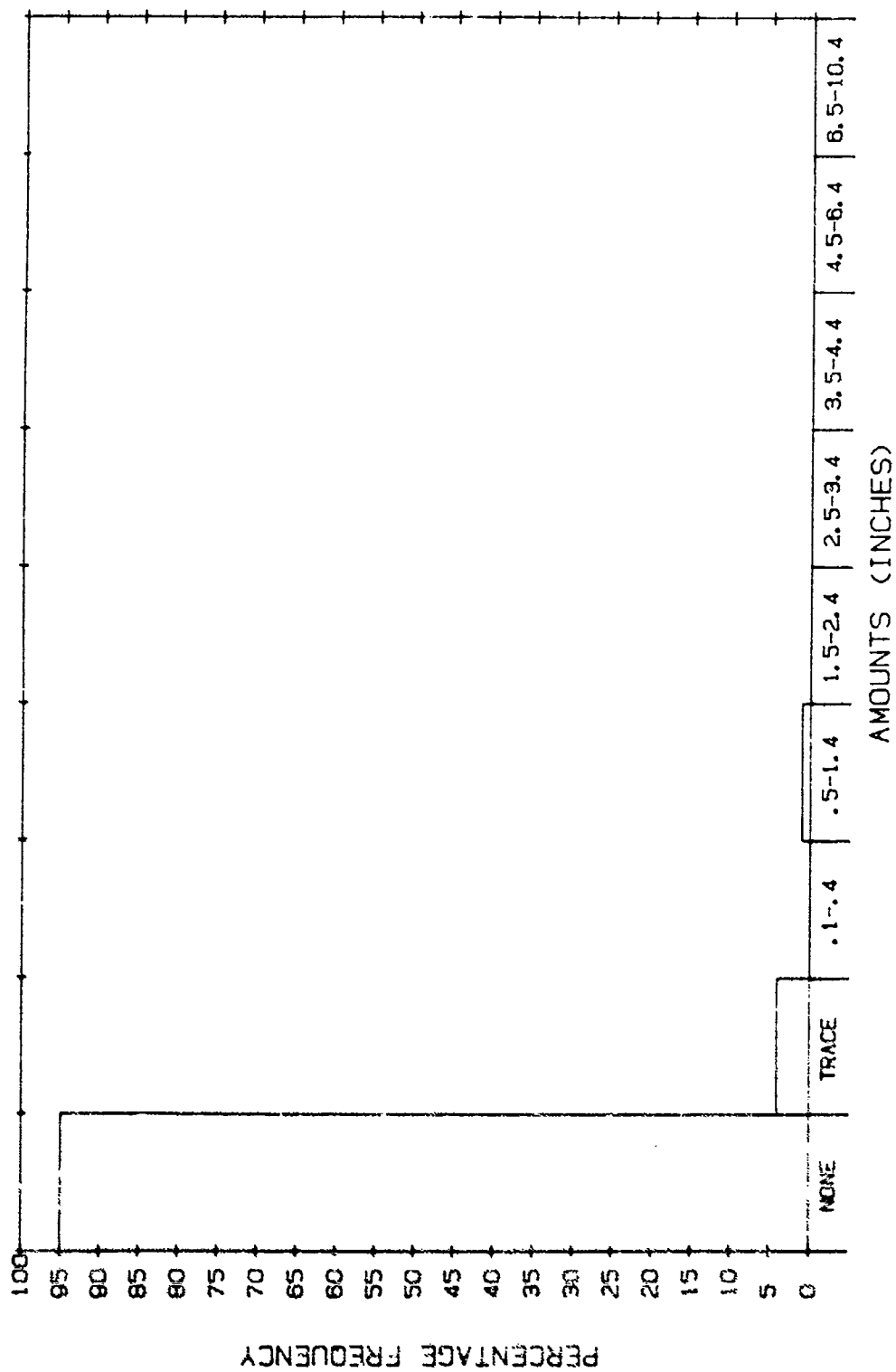


Figure A-132. Daily Amounts of Snowfall, Upper Heyford in November.

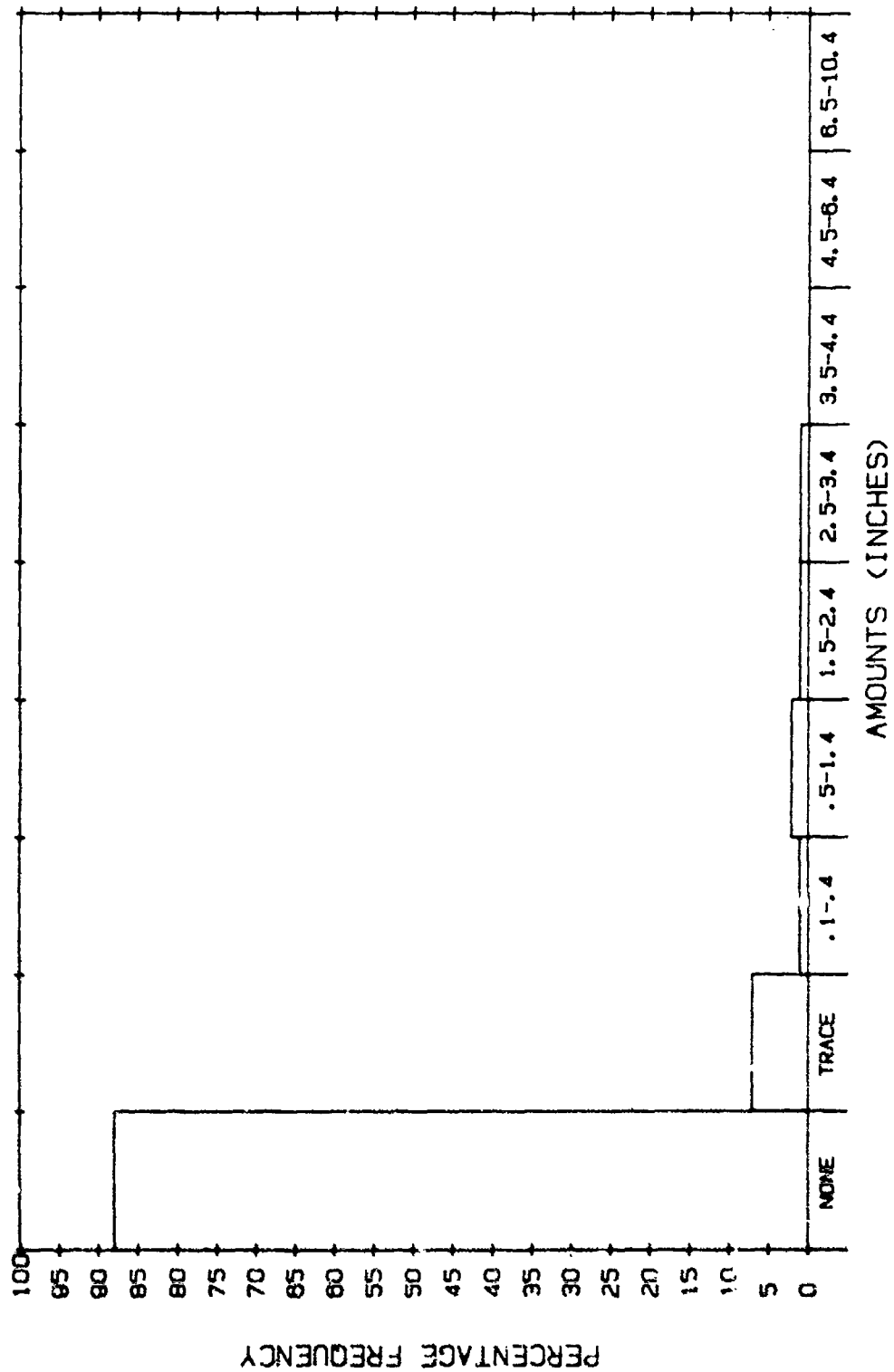


Figure A-133. Daily Amounts of Snowfall, Upper Heyford in December.

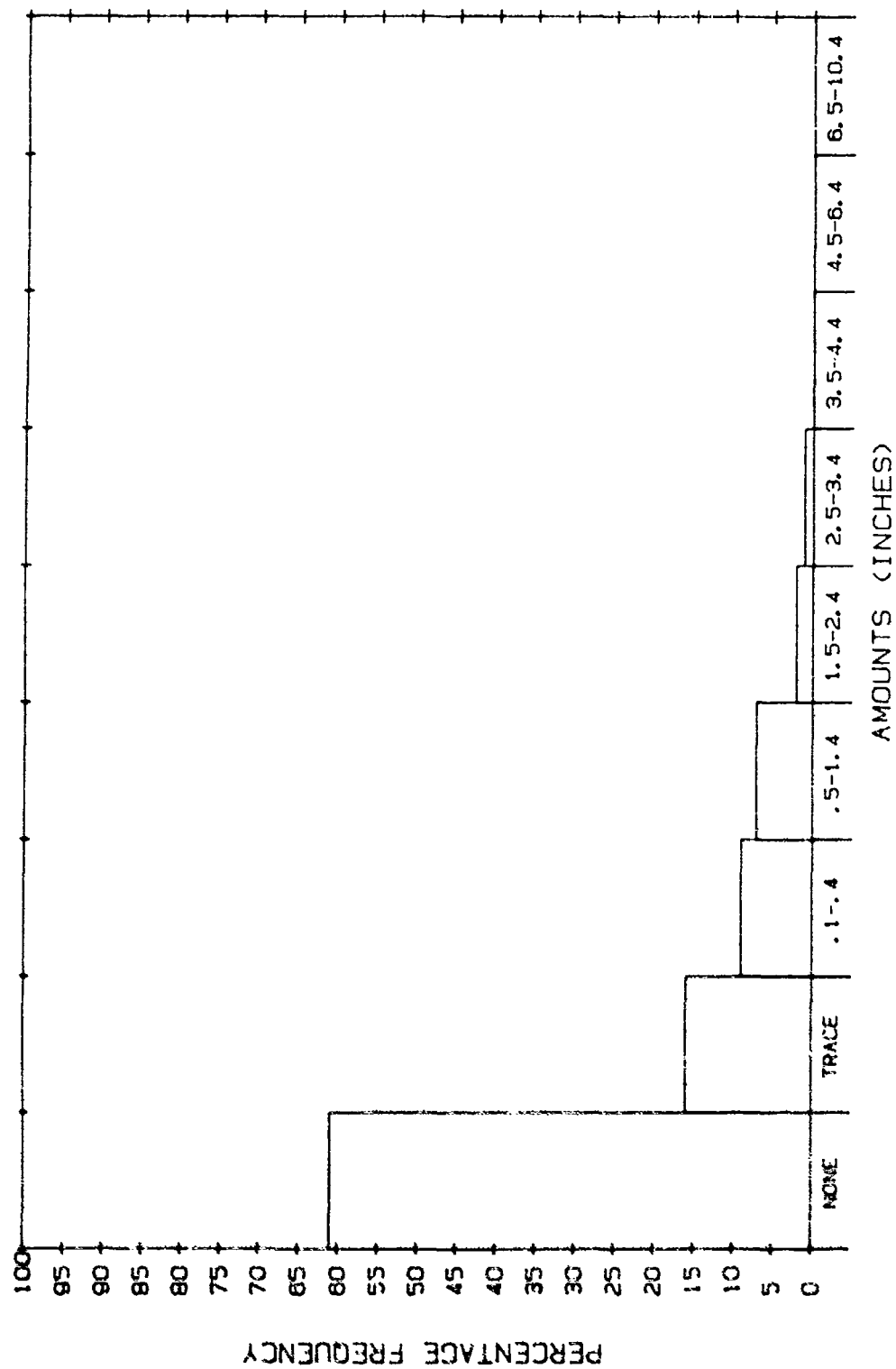


Figure A-134. Daily Amounts of Snowfall, Mean of German Airbases in January.

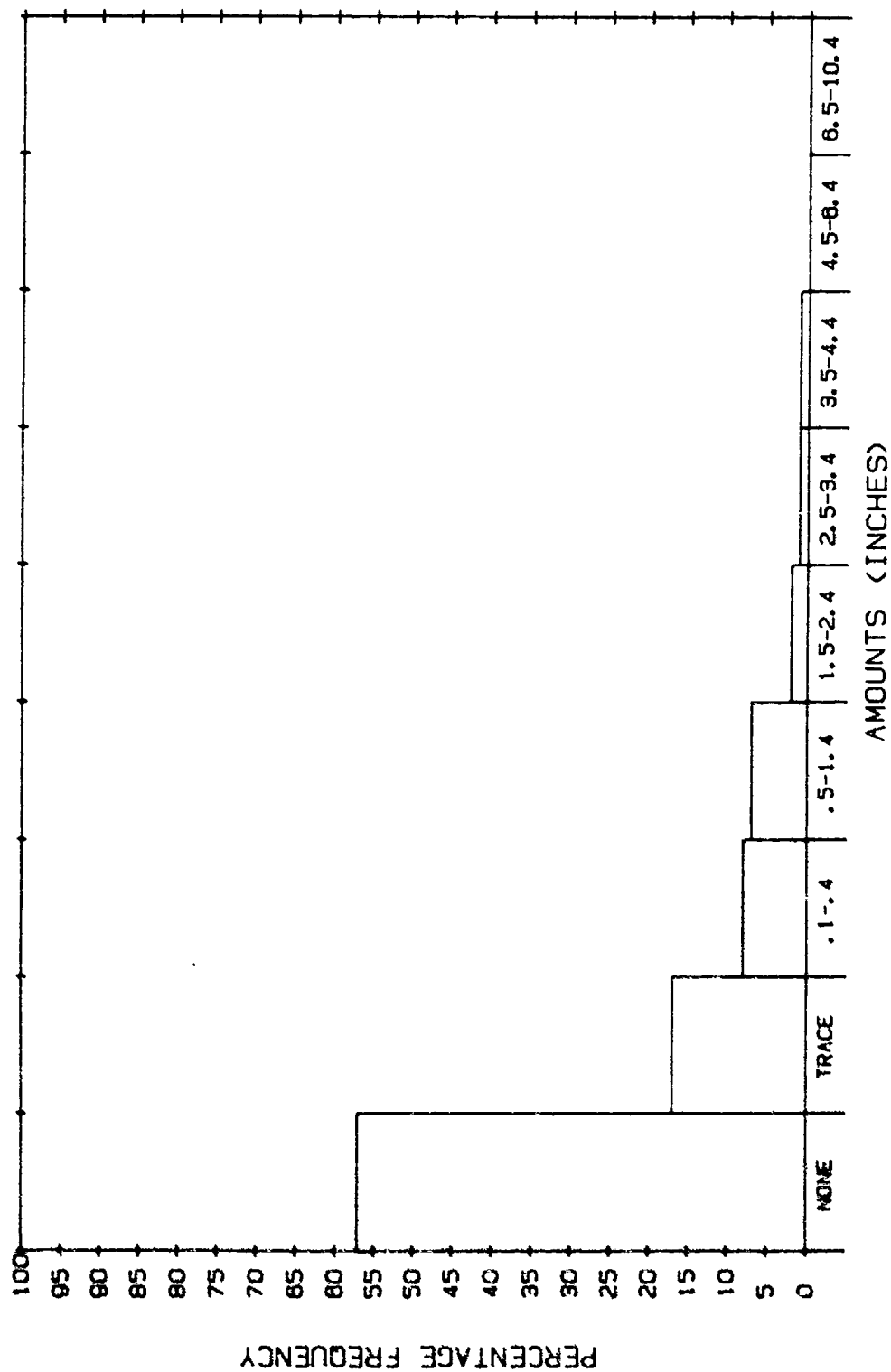


Figure A-135. Daily Amounts of Snowfall, Mean of German Airbases in February.

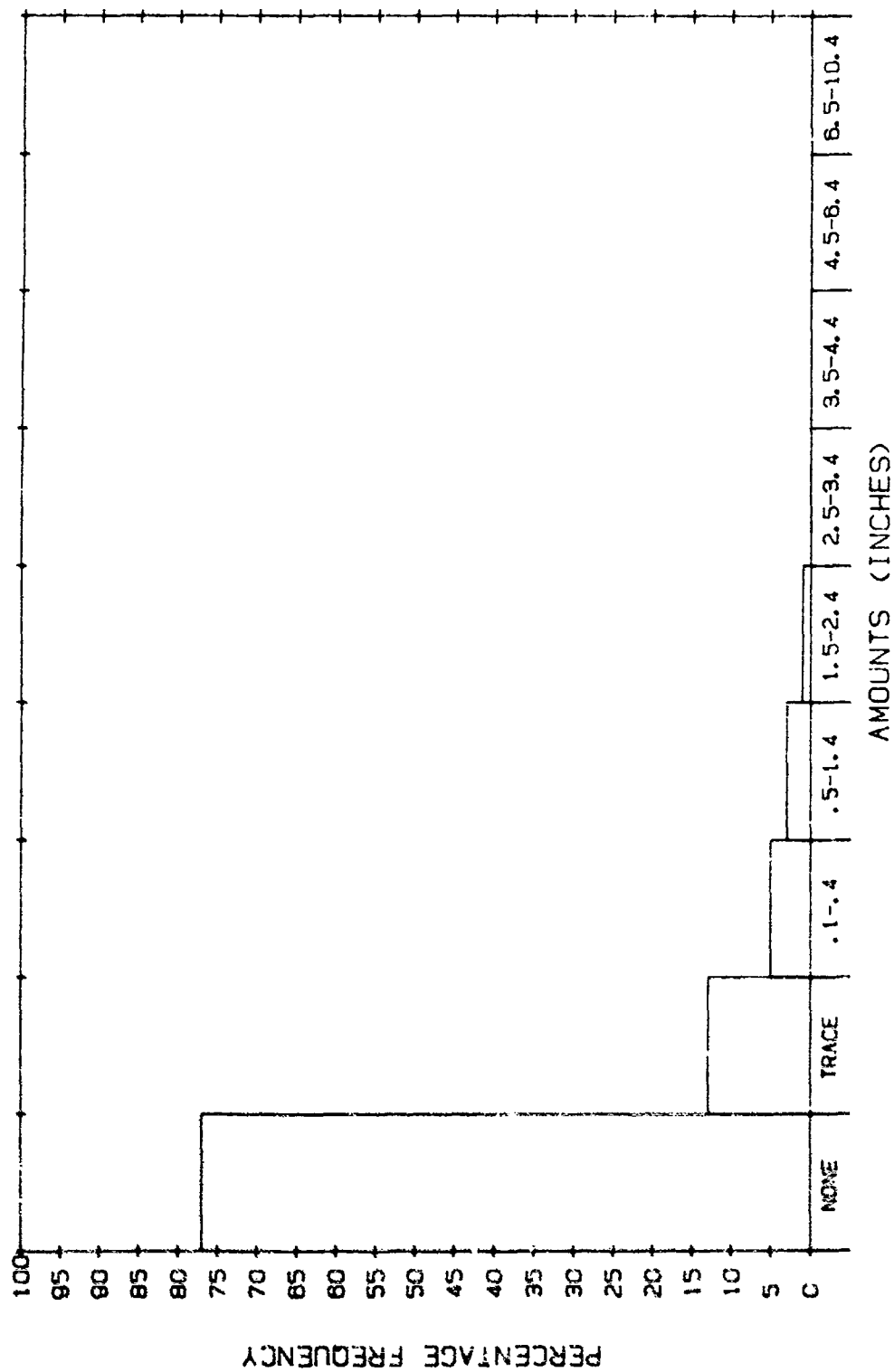


Figure A-136. Daily Amounts of Snowfall, Mean of German Airbases in March.

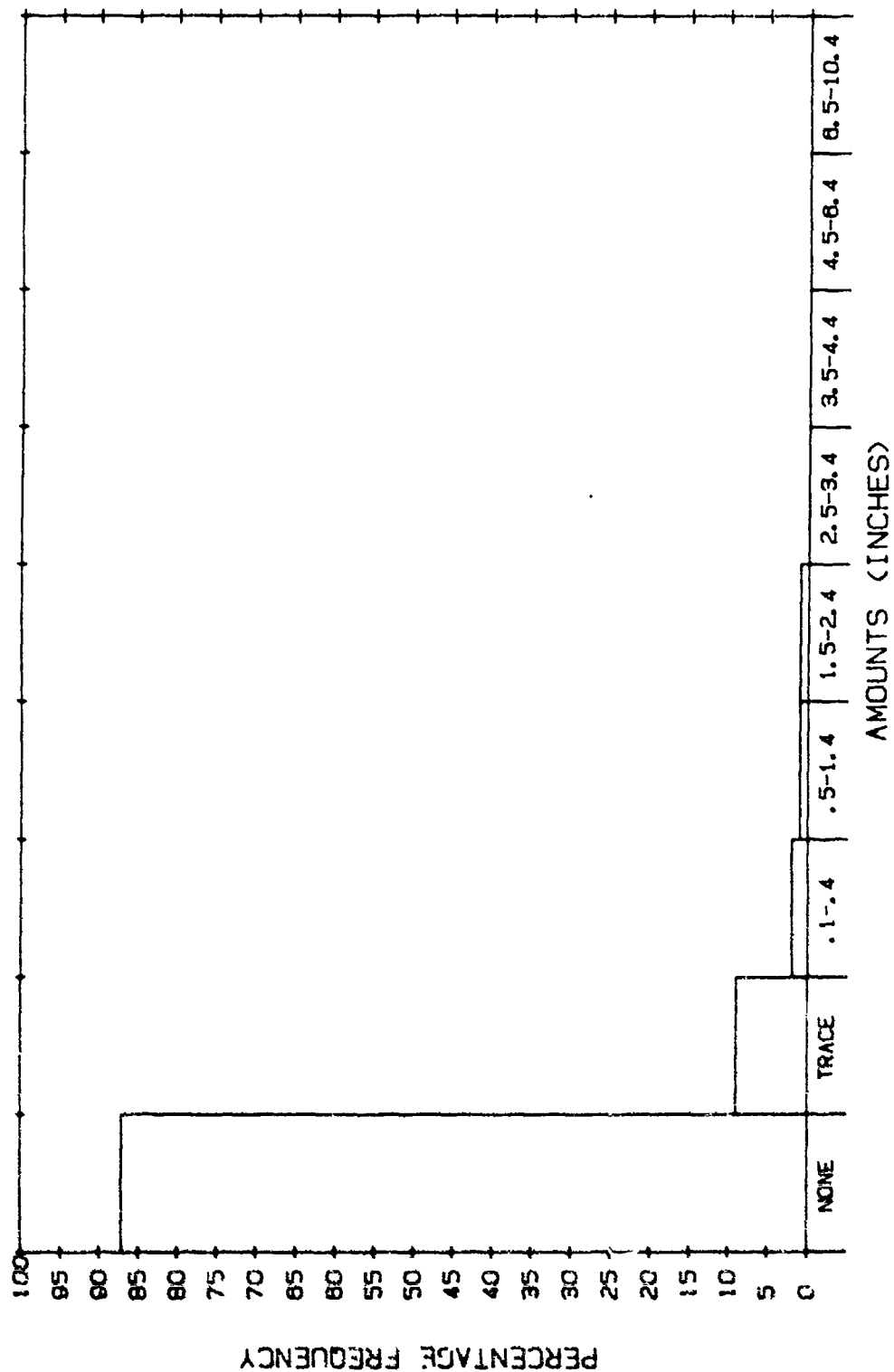


Figure A-137. Daily Amounts of Snowfall, Mean of German Airbases in April.

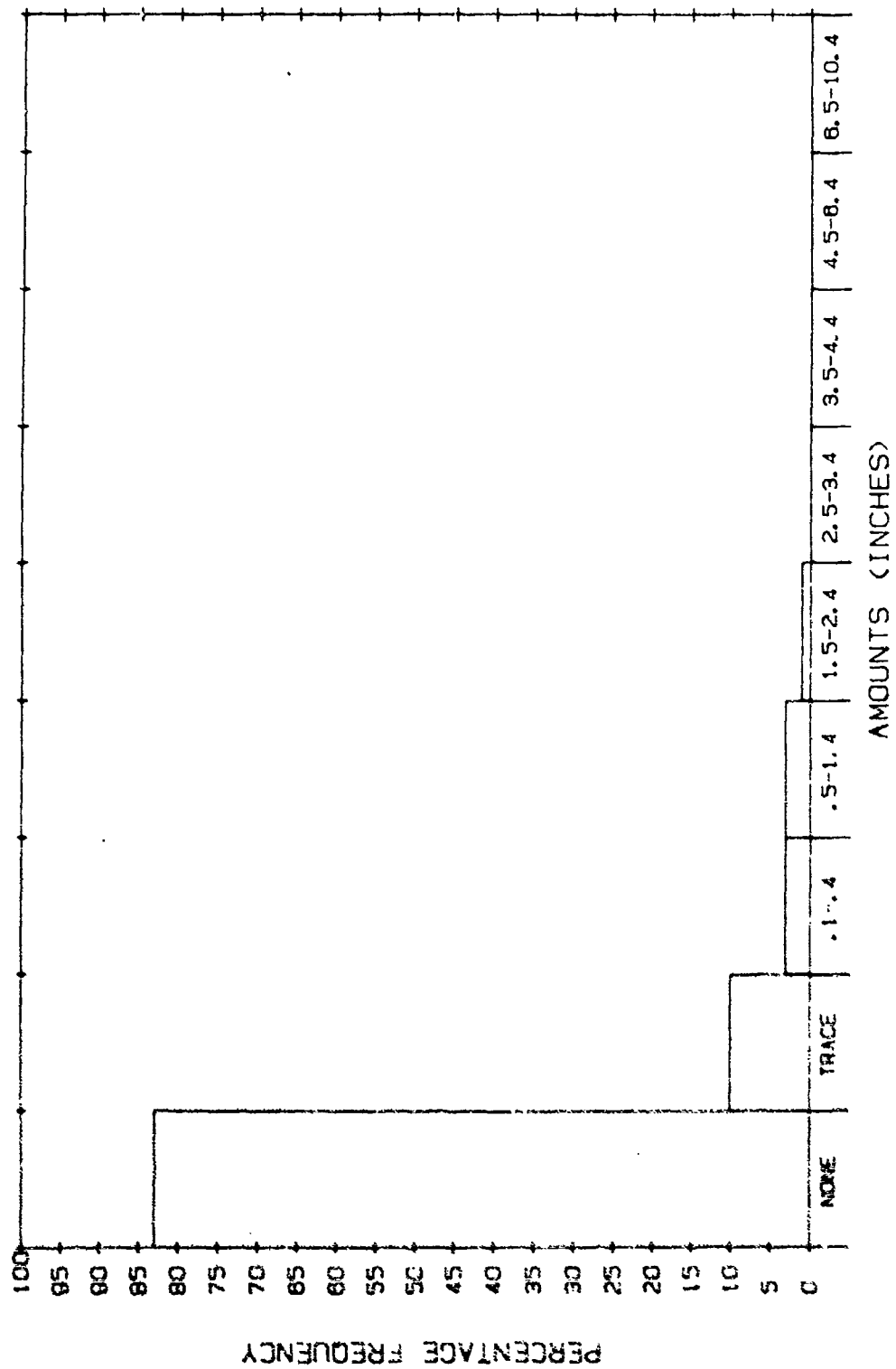


Figure A-138. Daily Amounts of Snowfall, Mean of German Airbases in November.

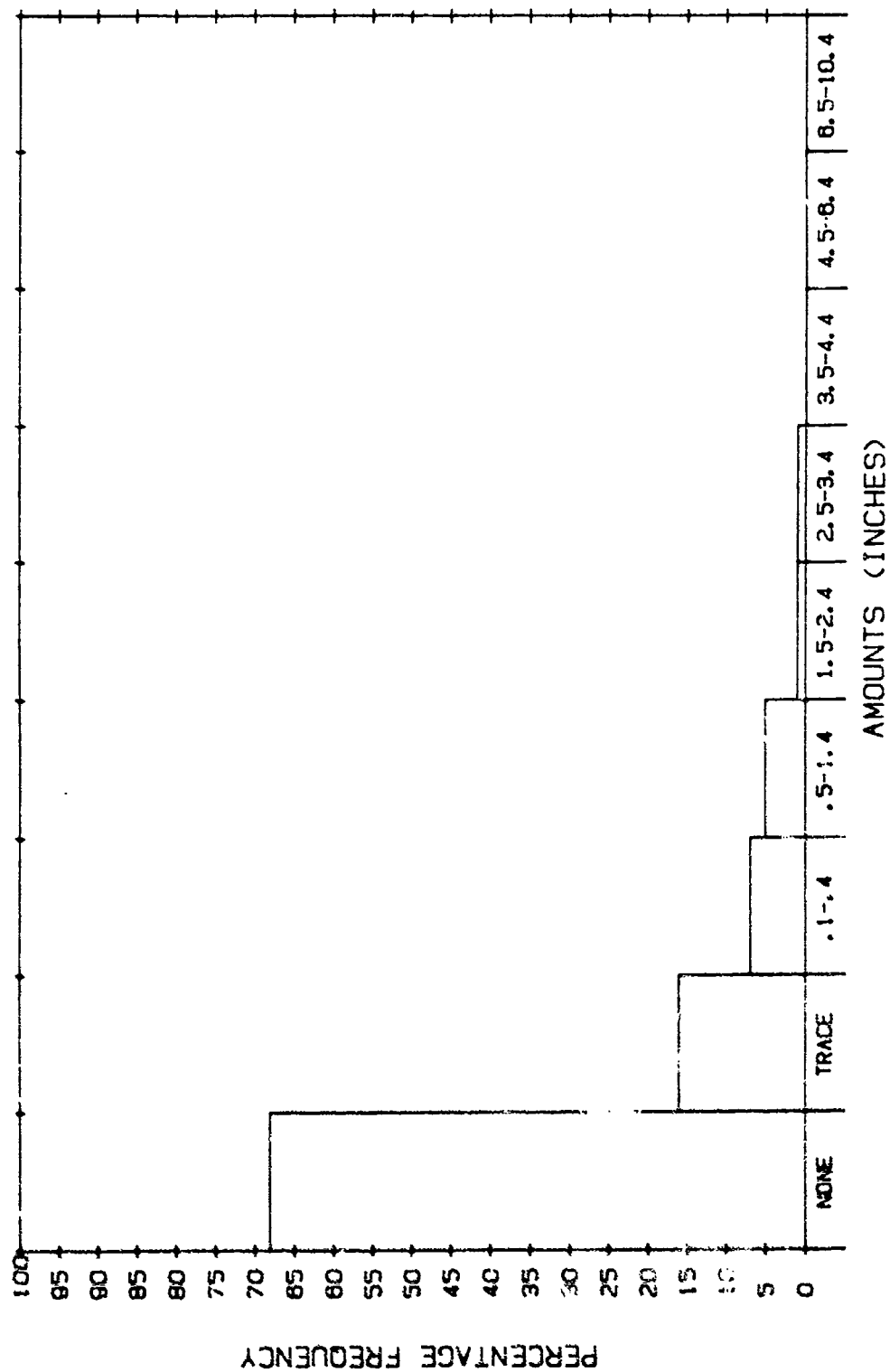


Figure A-139. Daily Amounts of Snowfall, Mean of German Airbases in December.

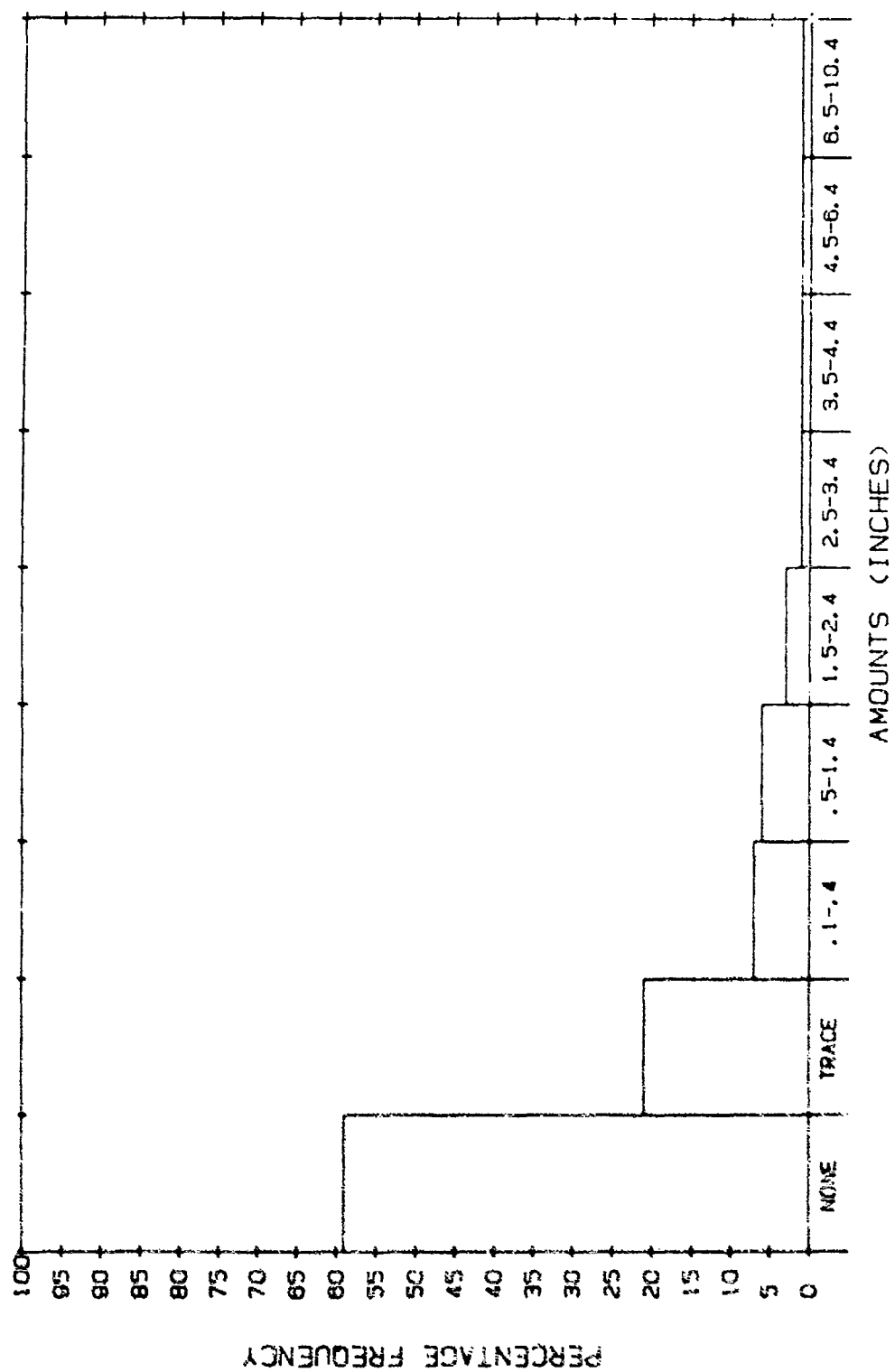


Figure A-140. Daily Amounts of Snowfall, Mean of Korean Airbases in January.

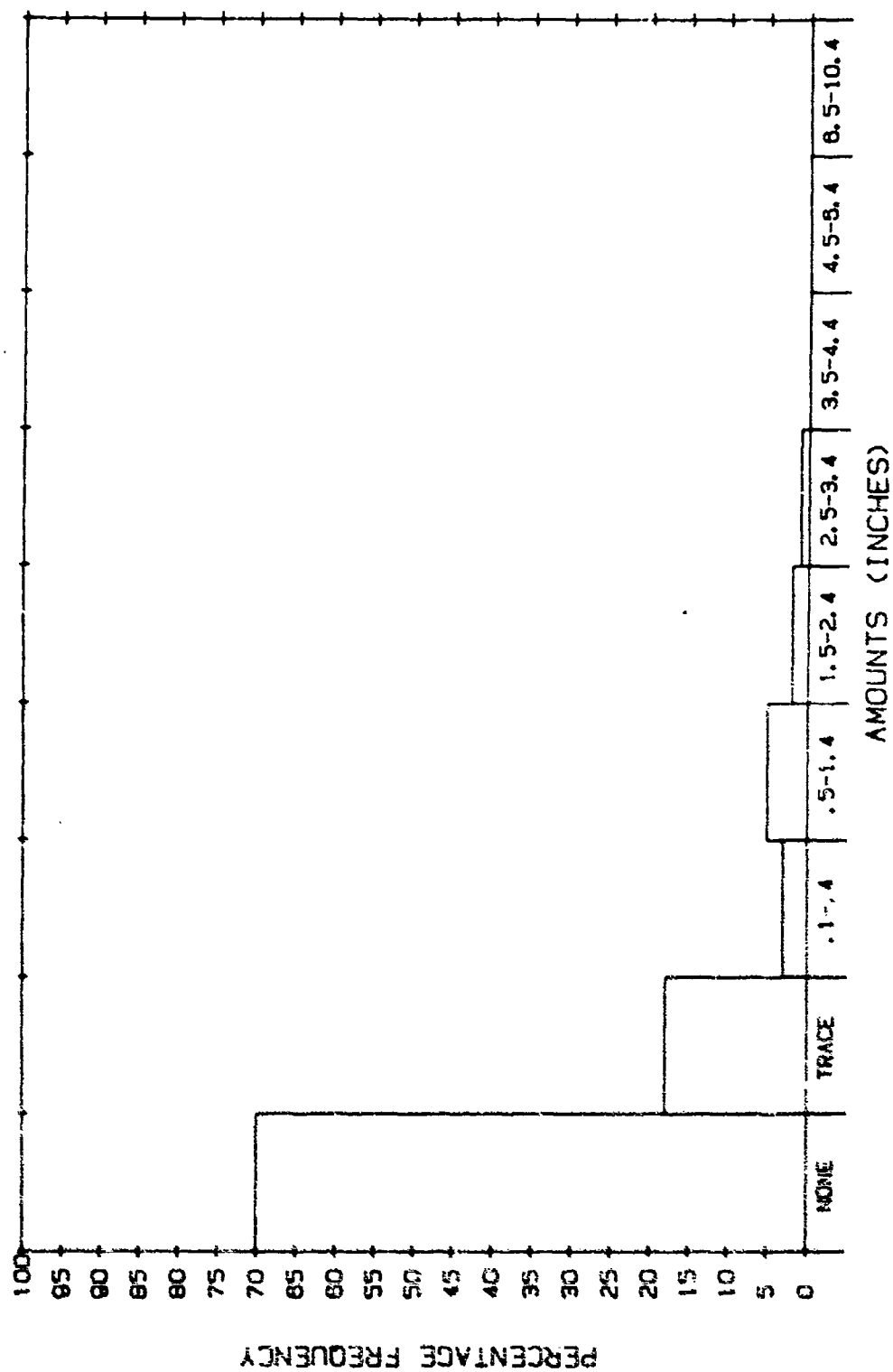


Figure A-141. Daily Amounts of Snowfall, Mean of Korean Airbases in February.

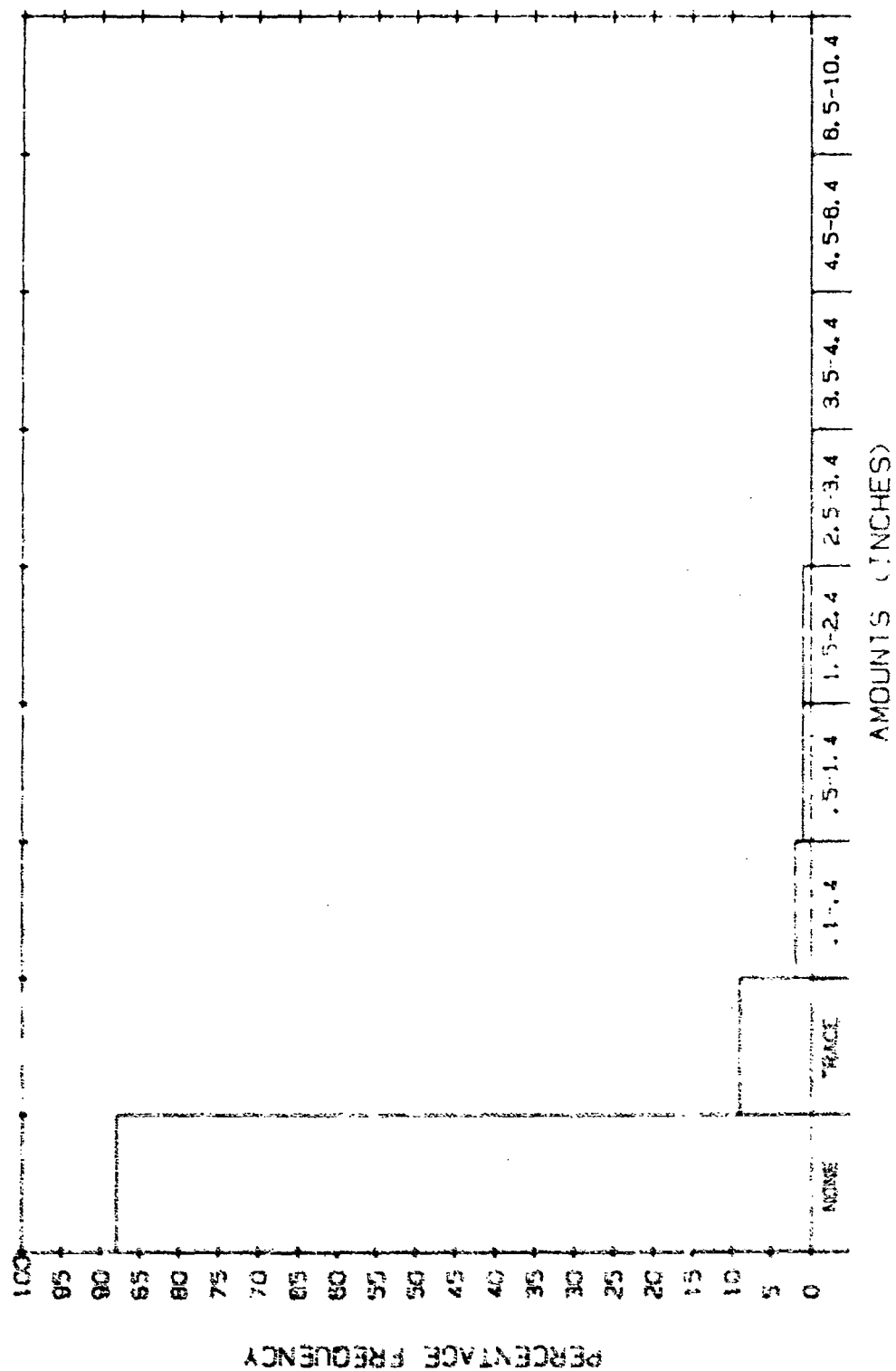


Figure A-142. Daily Amounts of Snowfall, Mean of Korean Airbases in March.

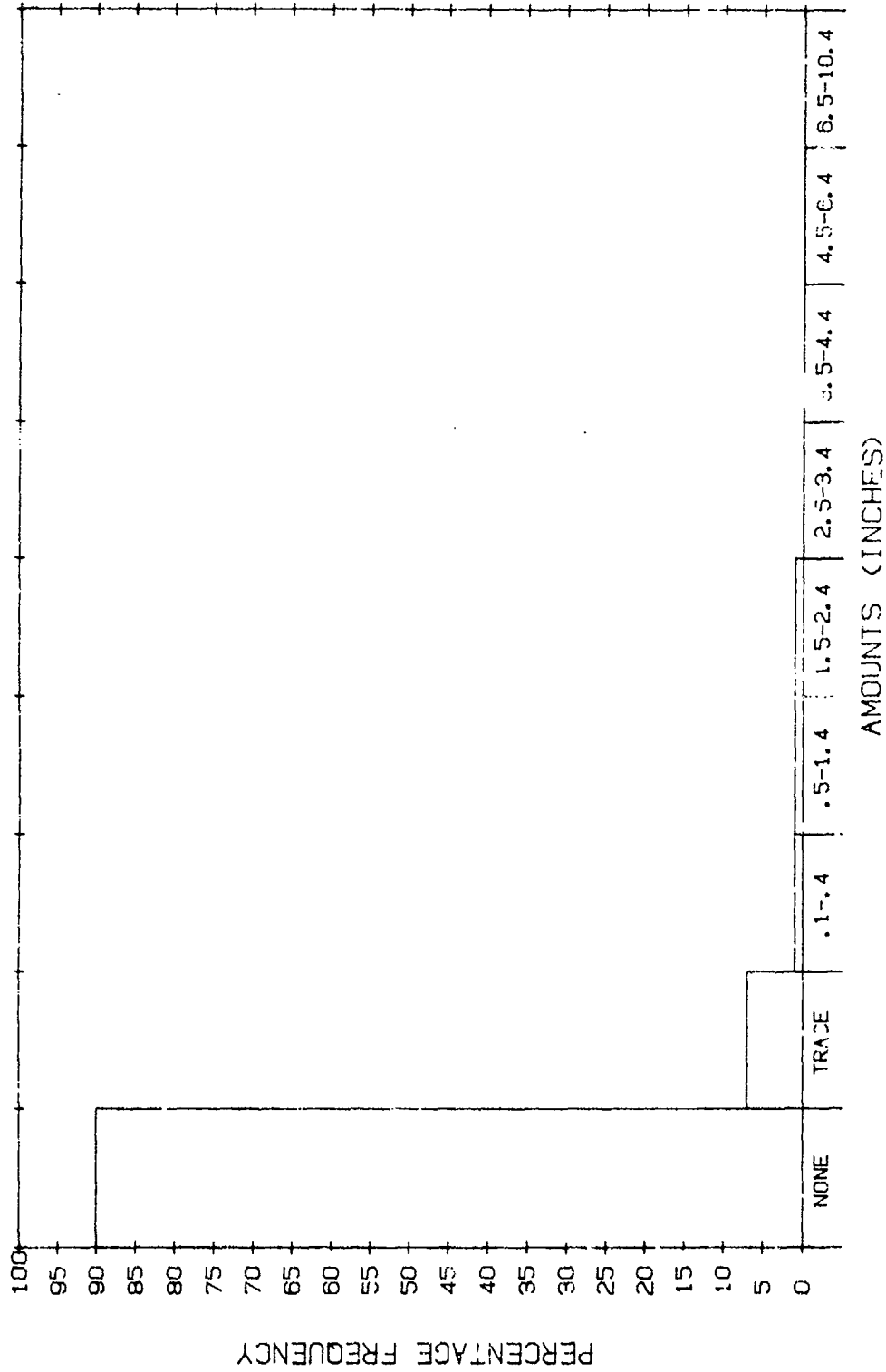


Figure A-143. Daily Amounts of Snowfall, Mean of Korean Airbases in November.

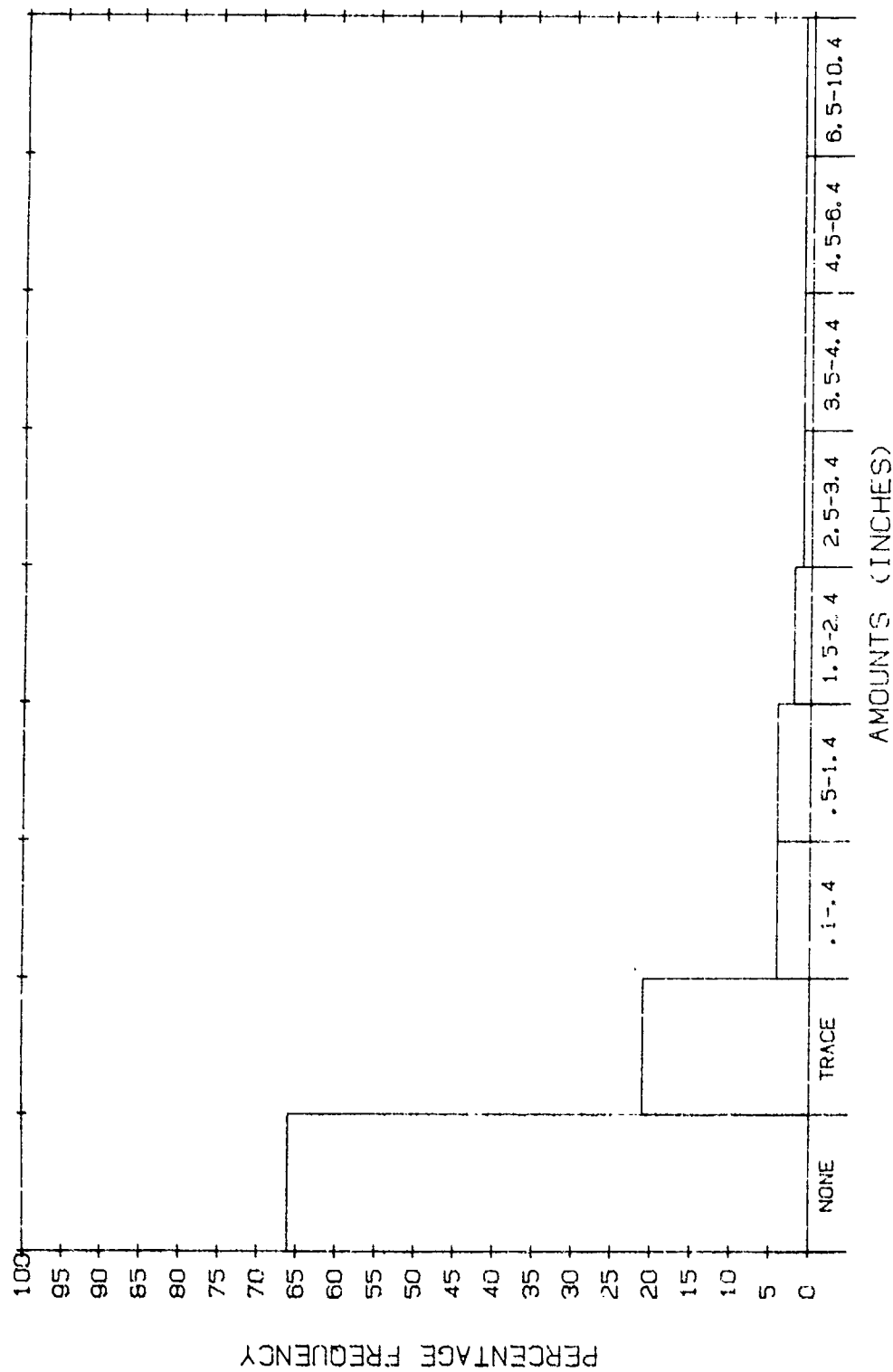


Figure A-144. Daily Amounts of Snowfall, Mean of Korean Airbases in December.

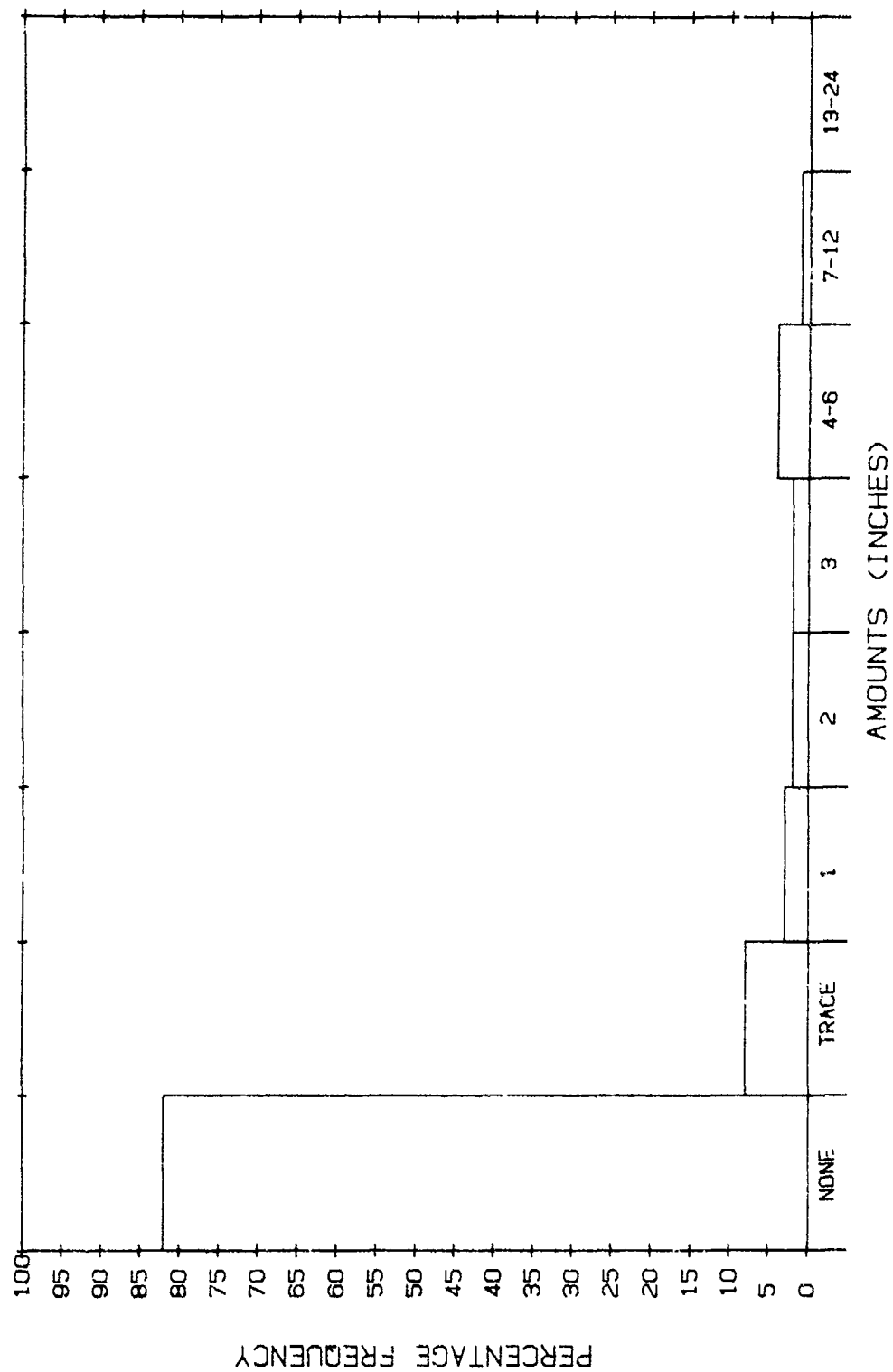


Figure A-145. Daily Amounts of Snowdepth, Upper Heyford in January.

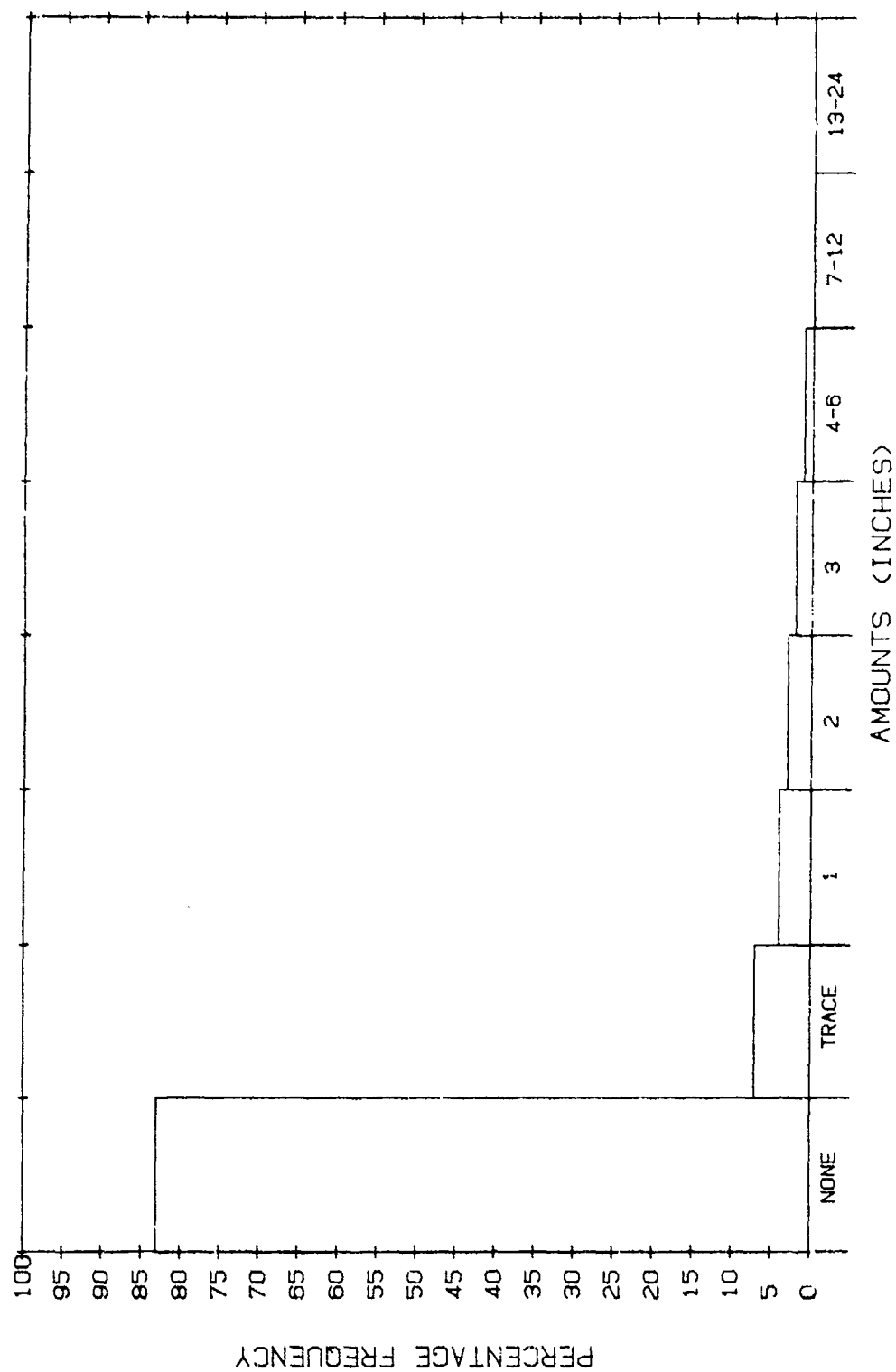


Figure A-146. Daily Amounts of Snowdepth, Upper Heyford in February.

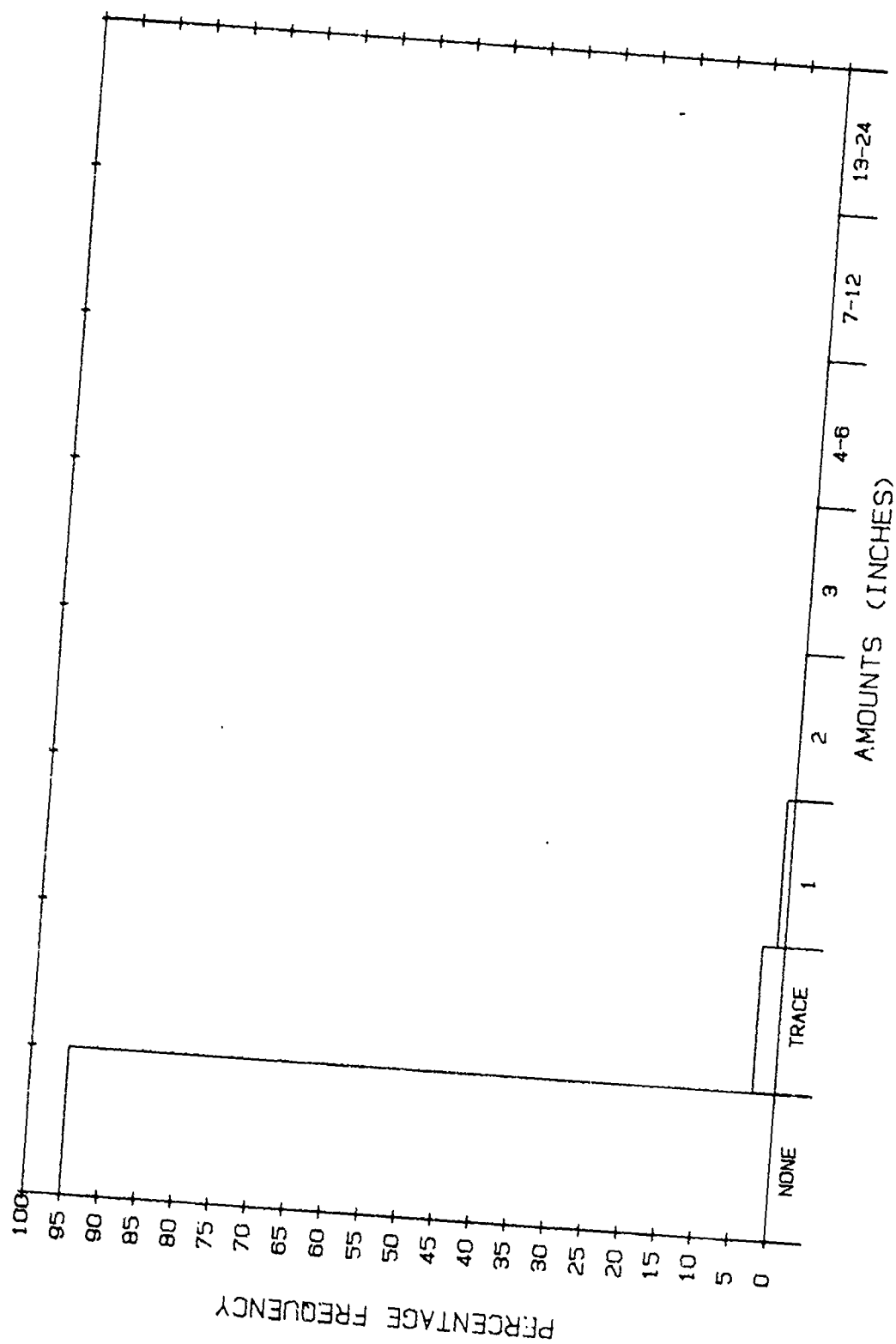


Figure A-147. Daily Amounts of Snowdepth, Upper Heyford in March.

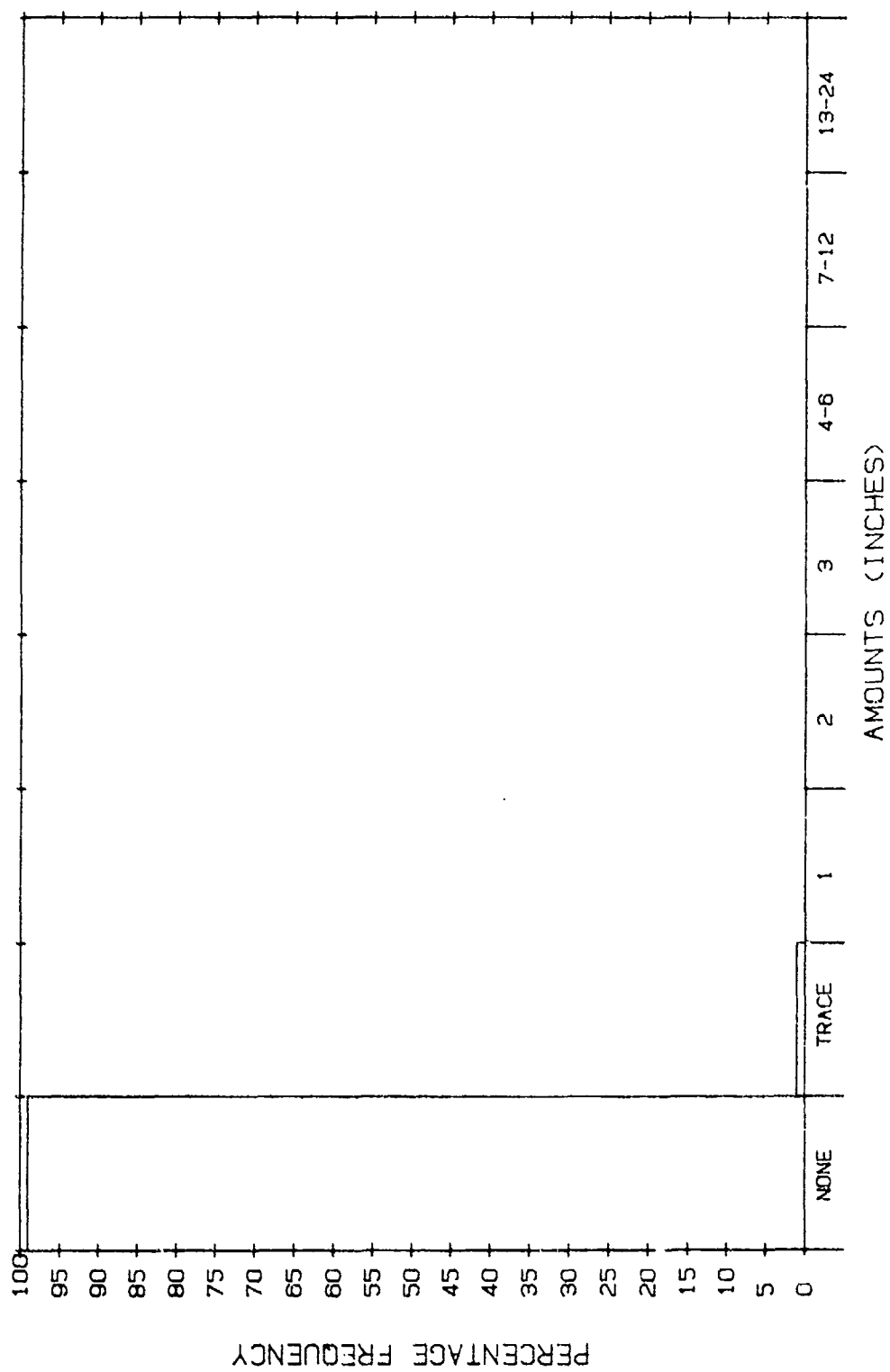


Figure A-148. Daily Amounts of Snowdepth, Upper Heyford in November.

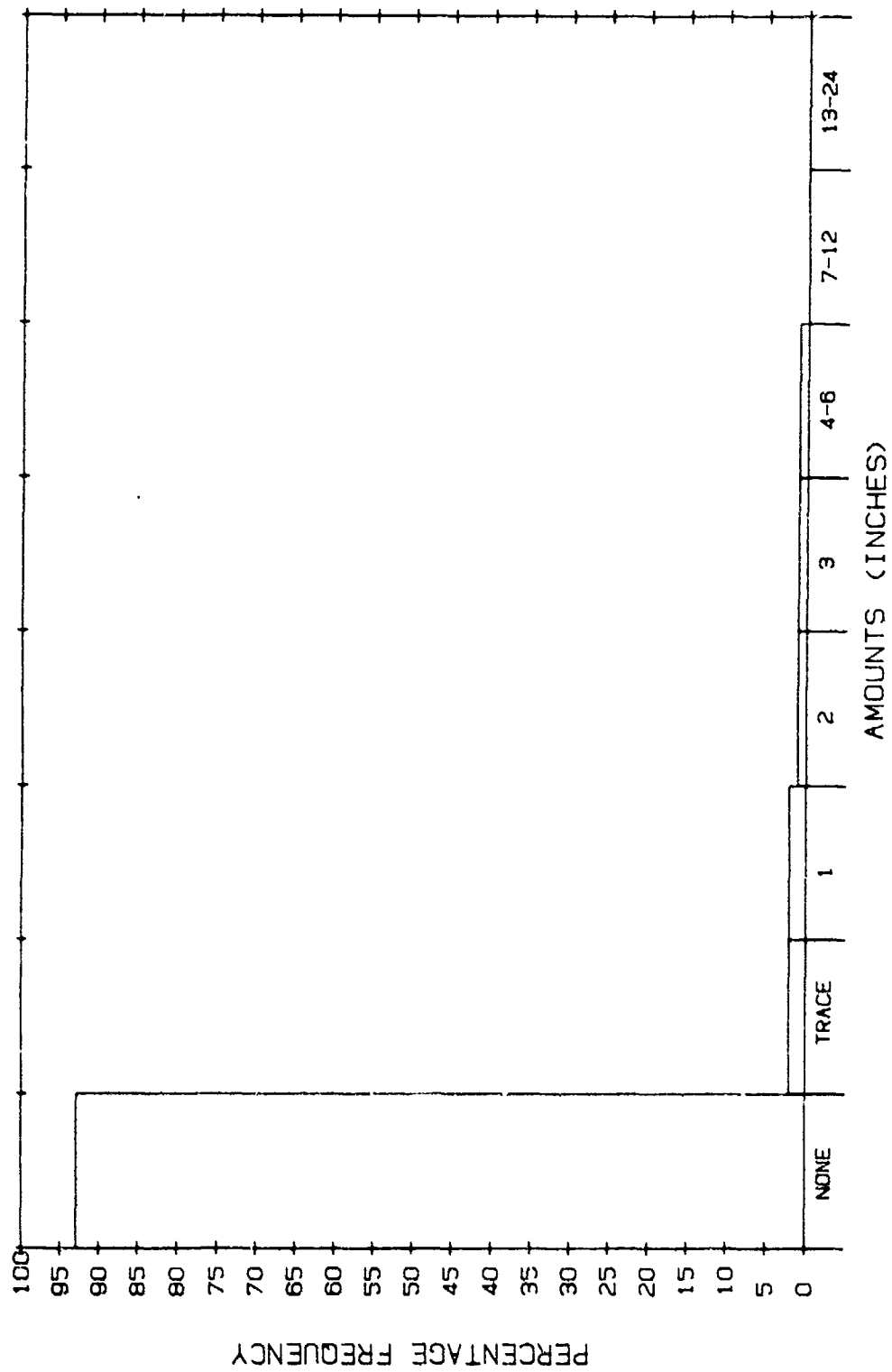


Figure A-149. Daily Amounts of Snowdepth, Upper Heyford in December.

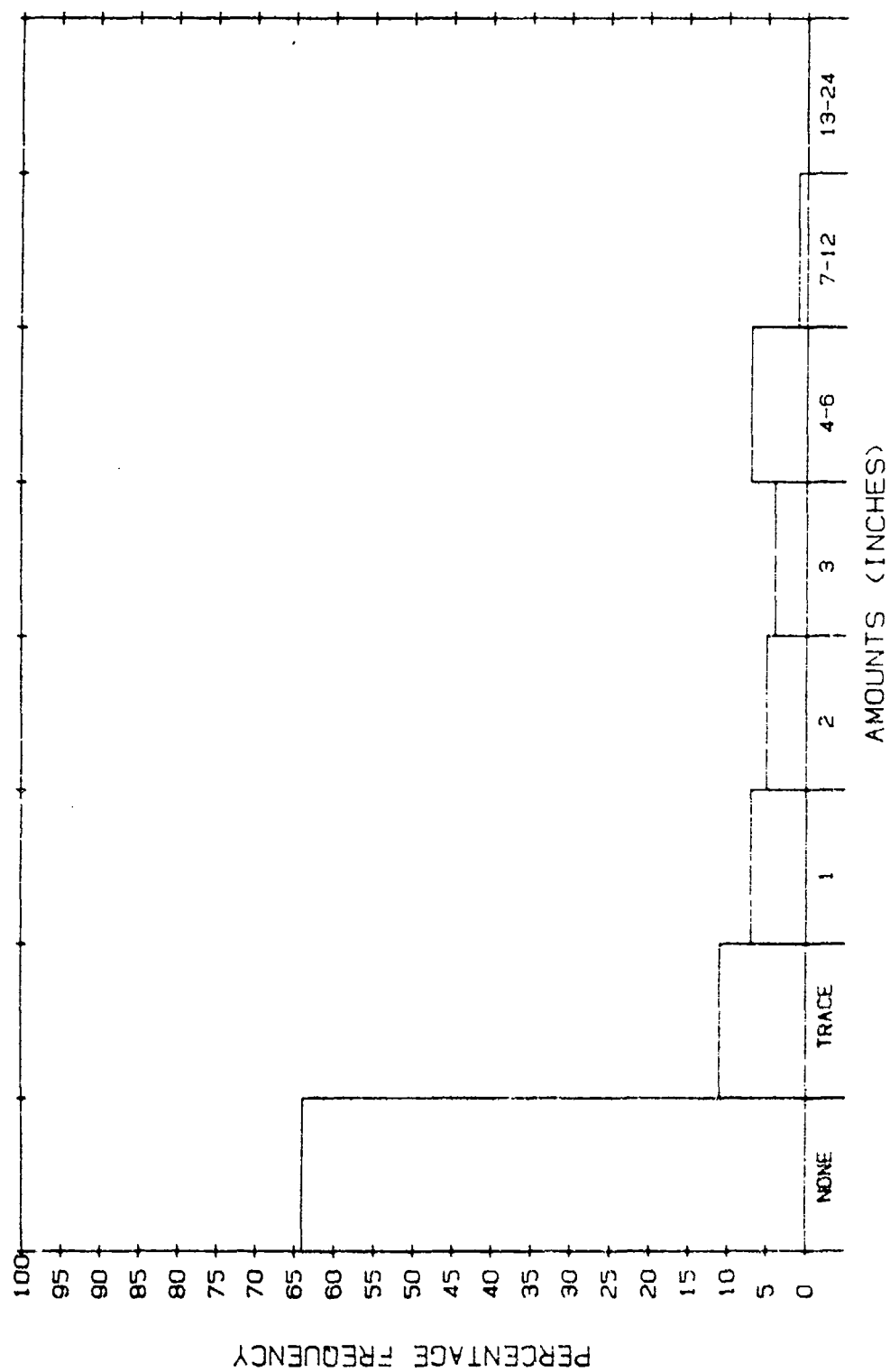


Figure A-150. Daily Amounts of Snowdepth, Mean of German Airbases in January.

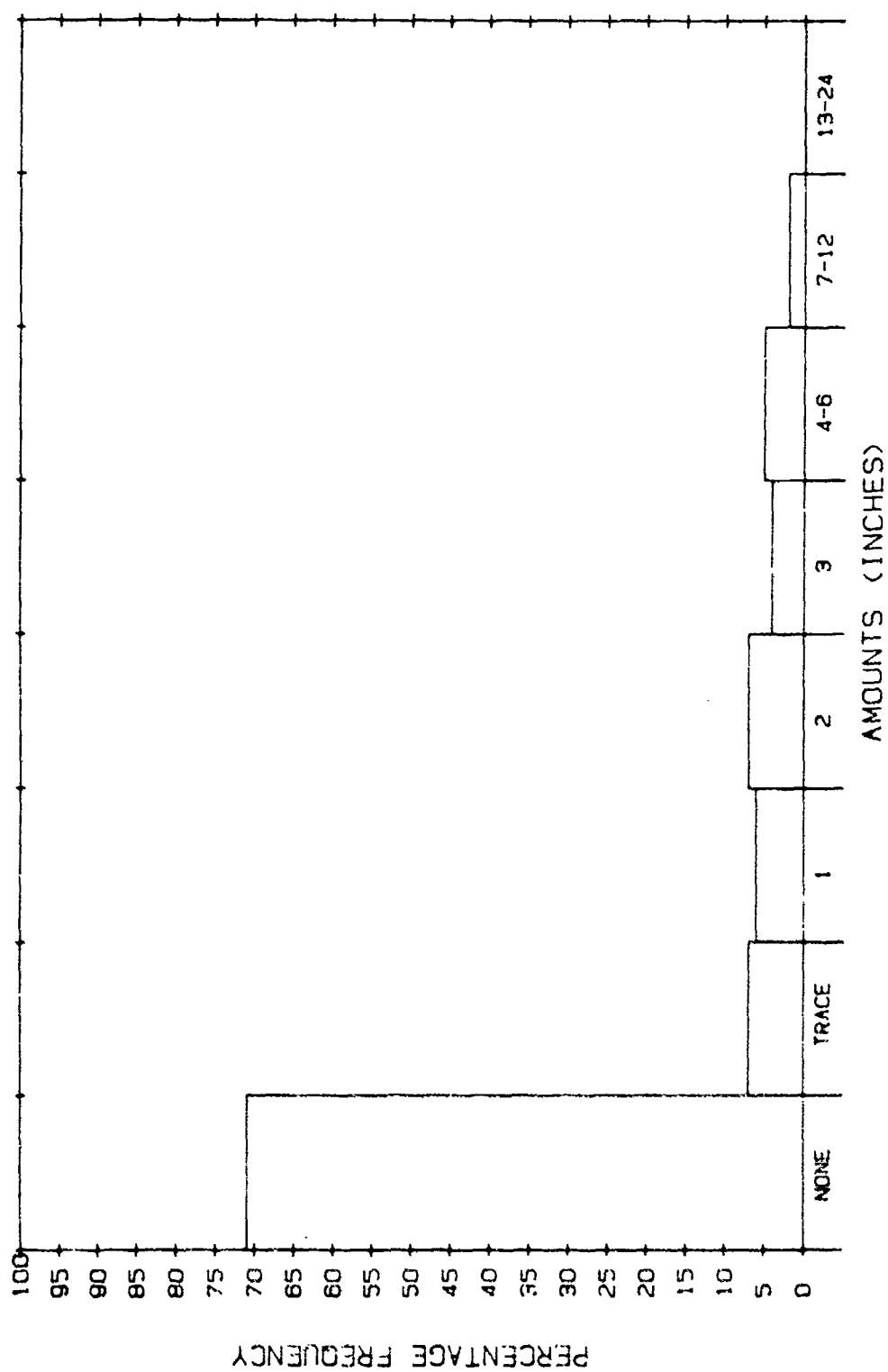


Figure A-151. Daily Amounts of Snowdepth, Mean of German Airbases in February.

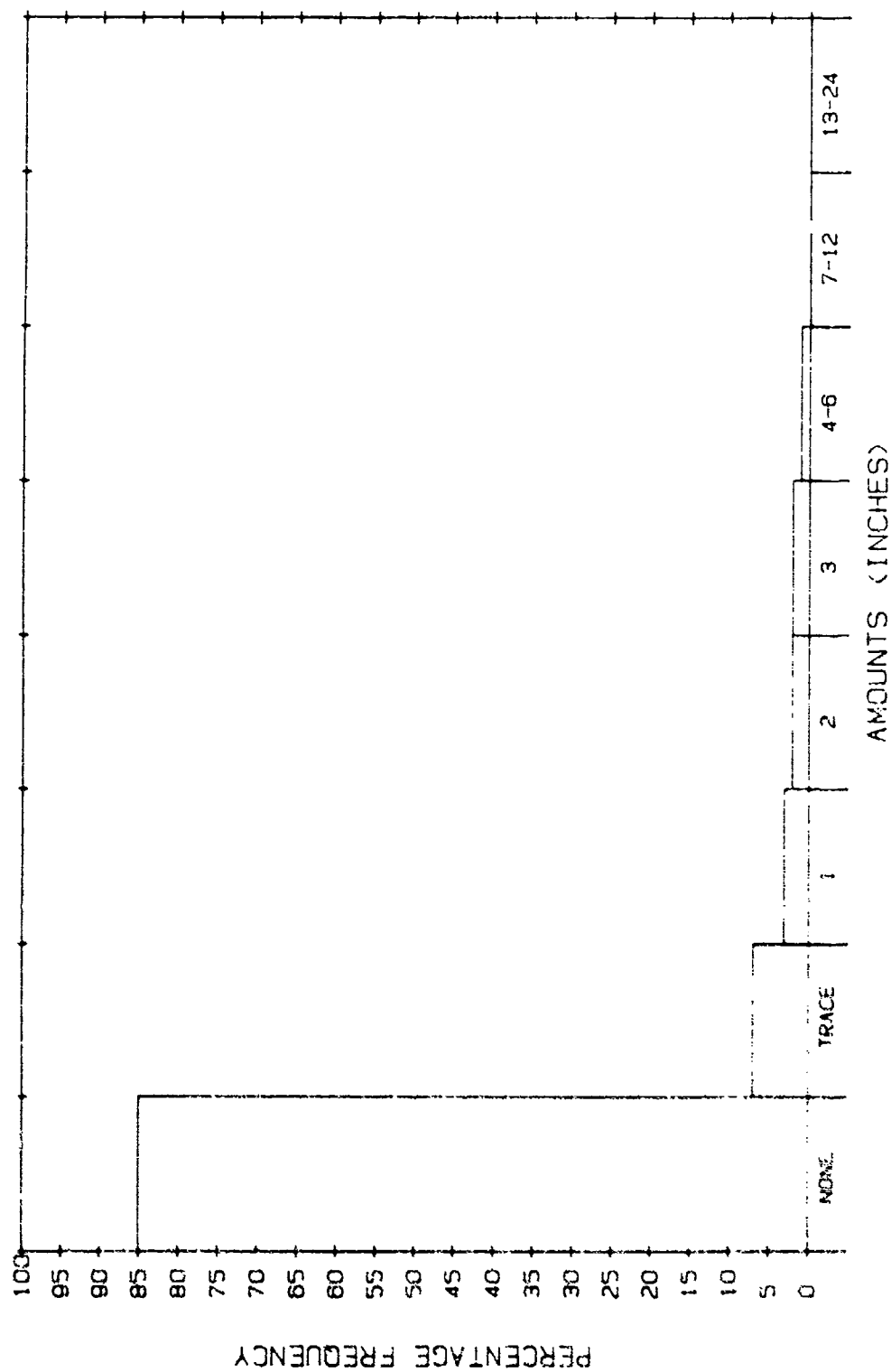


Figure A-152. Daily Amounts of Snowdepth, Mean of German Airbases in March.

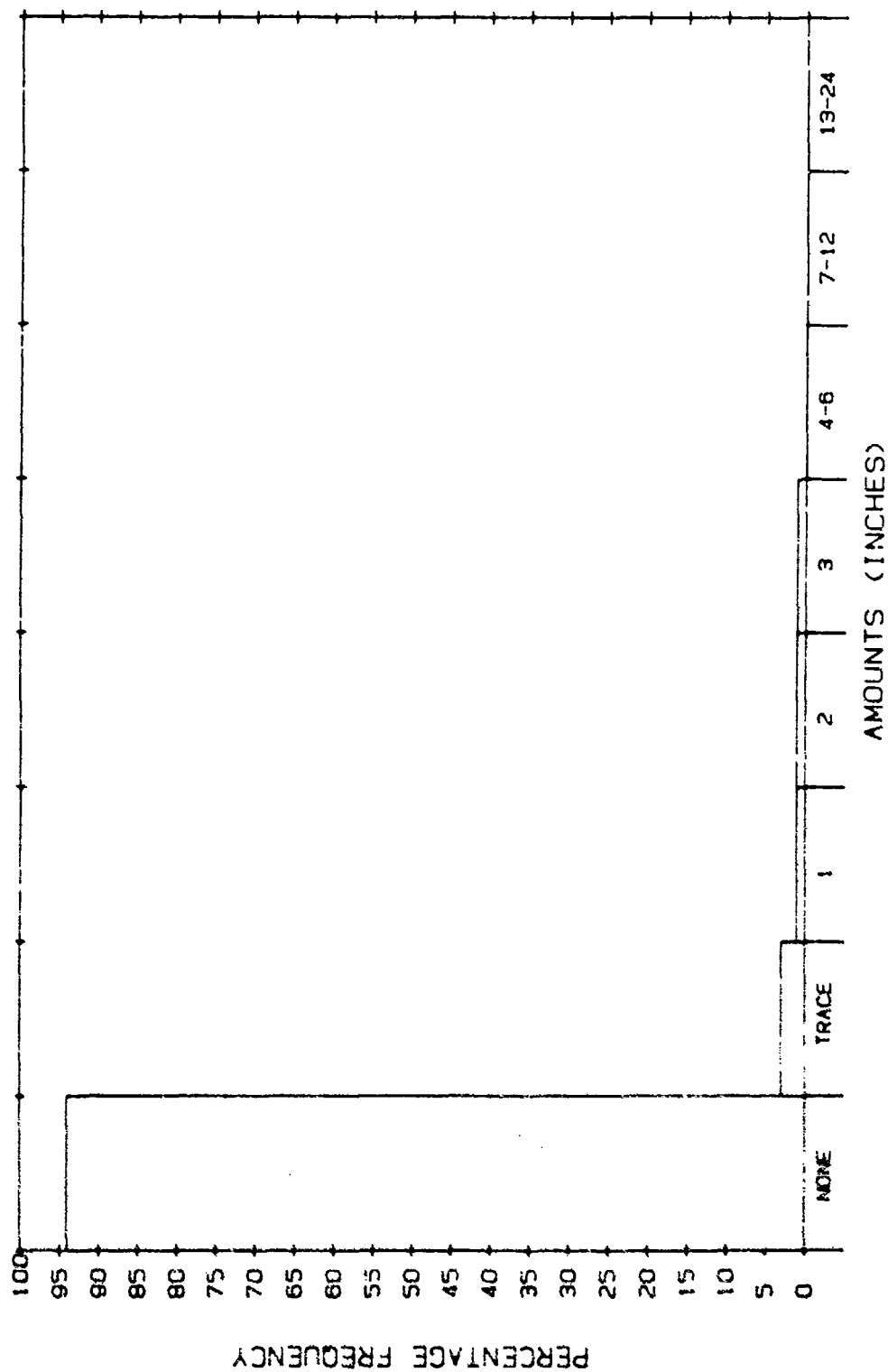


Figure A-153. Daily Amounts of Snowdepth, Mean of German Airbases in November.

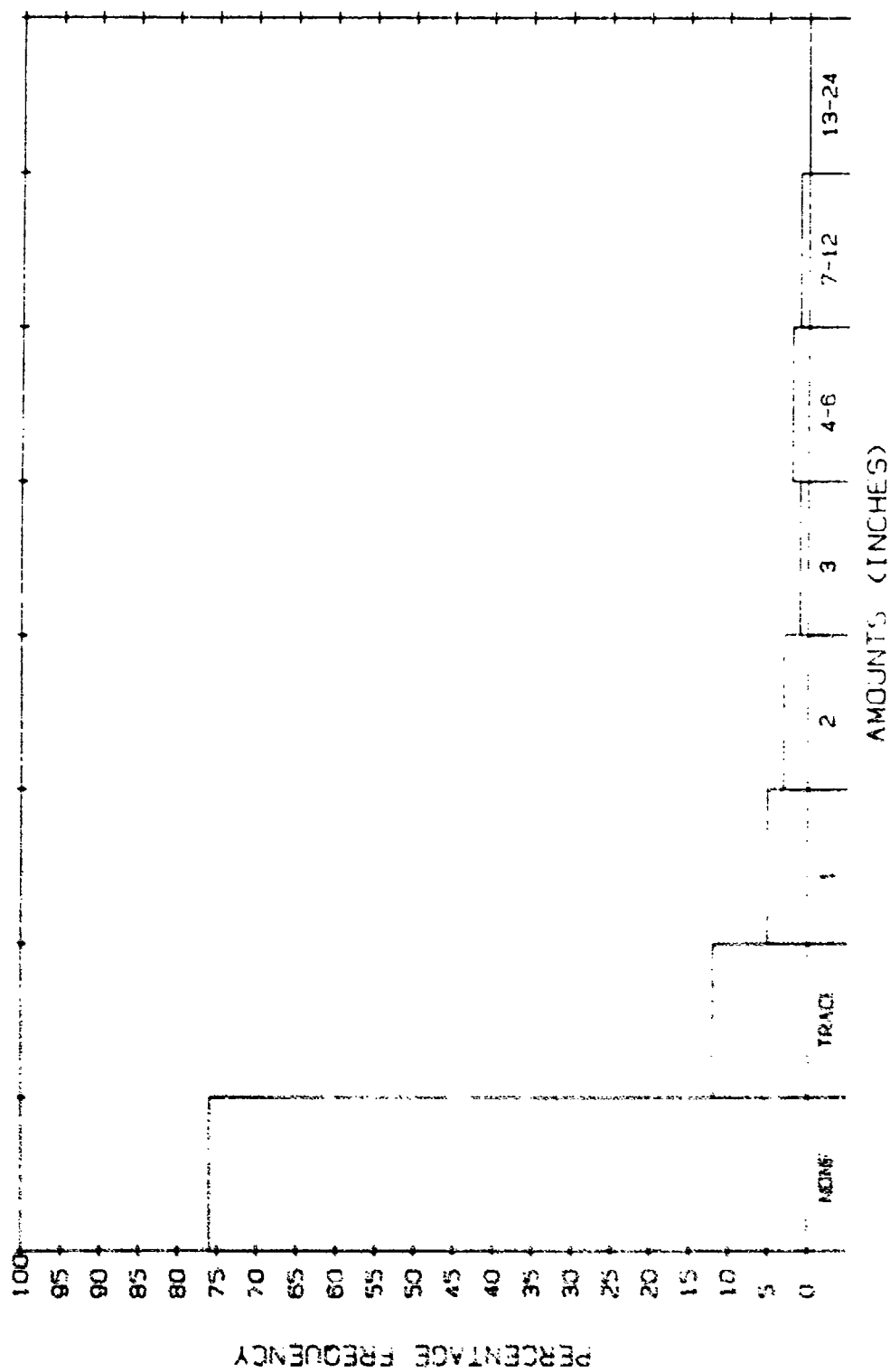


Figure A-154. Daily Amounts of Snowdepth, Mean of German Airbases in December.

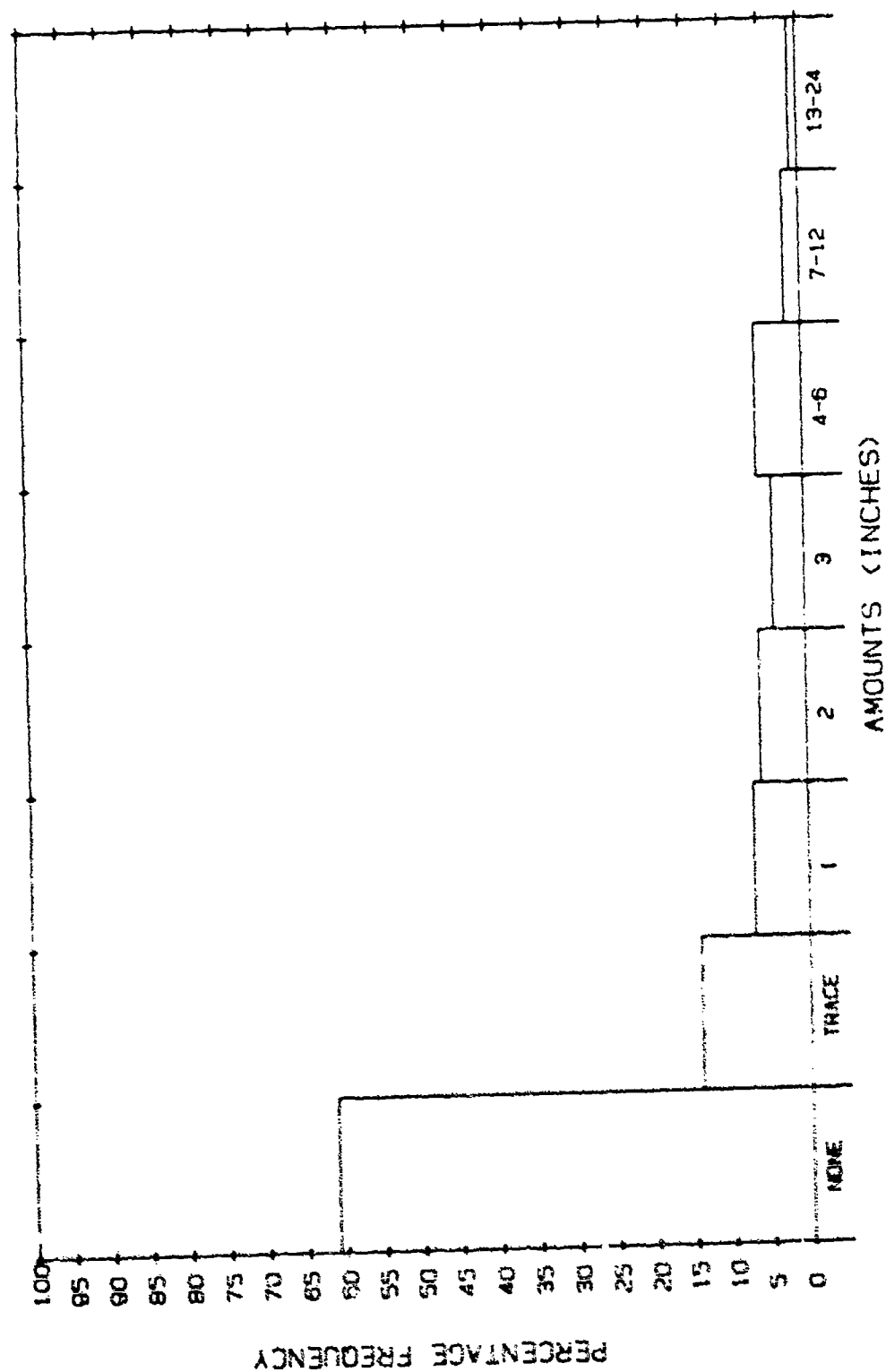


Figure A-155. Daily Amounts of Snowdepth, Mean of Korean Airbases in January.

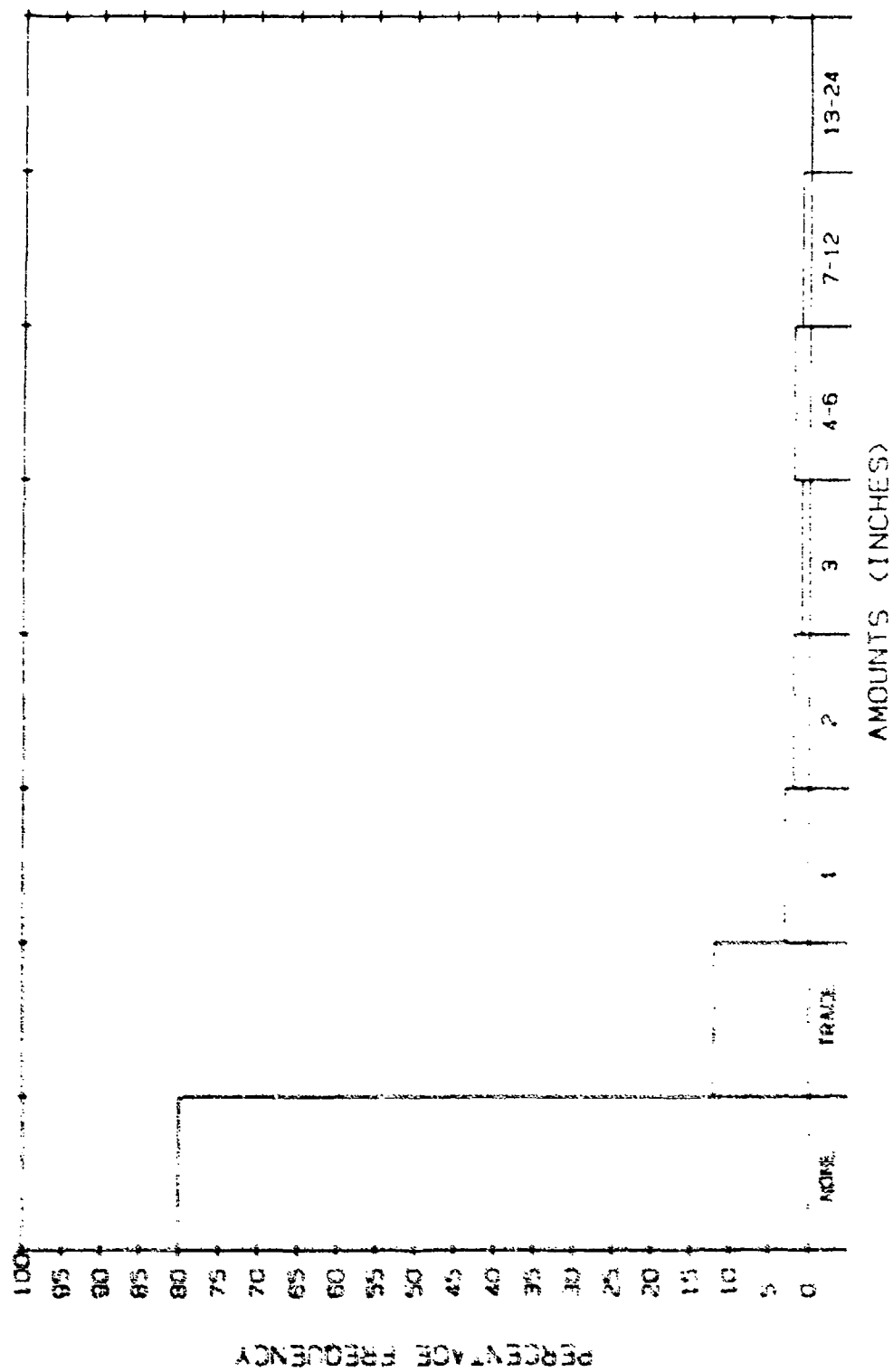


Figure A-156. Daily Amounts of Snowdepth, Mean of Korean Airbases in February.

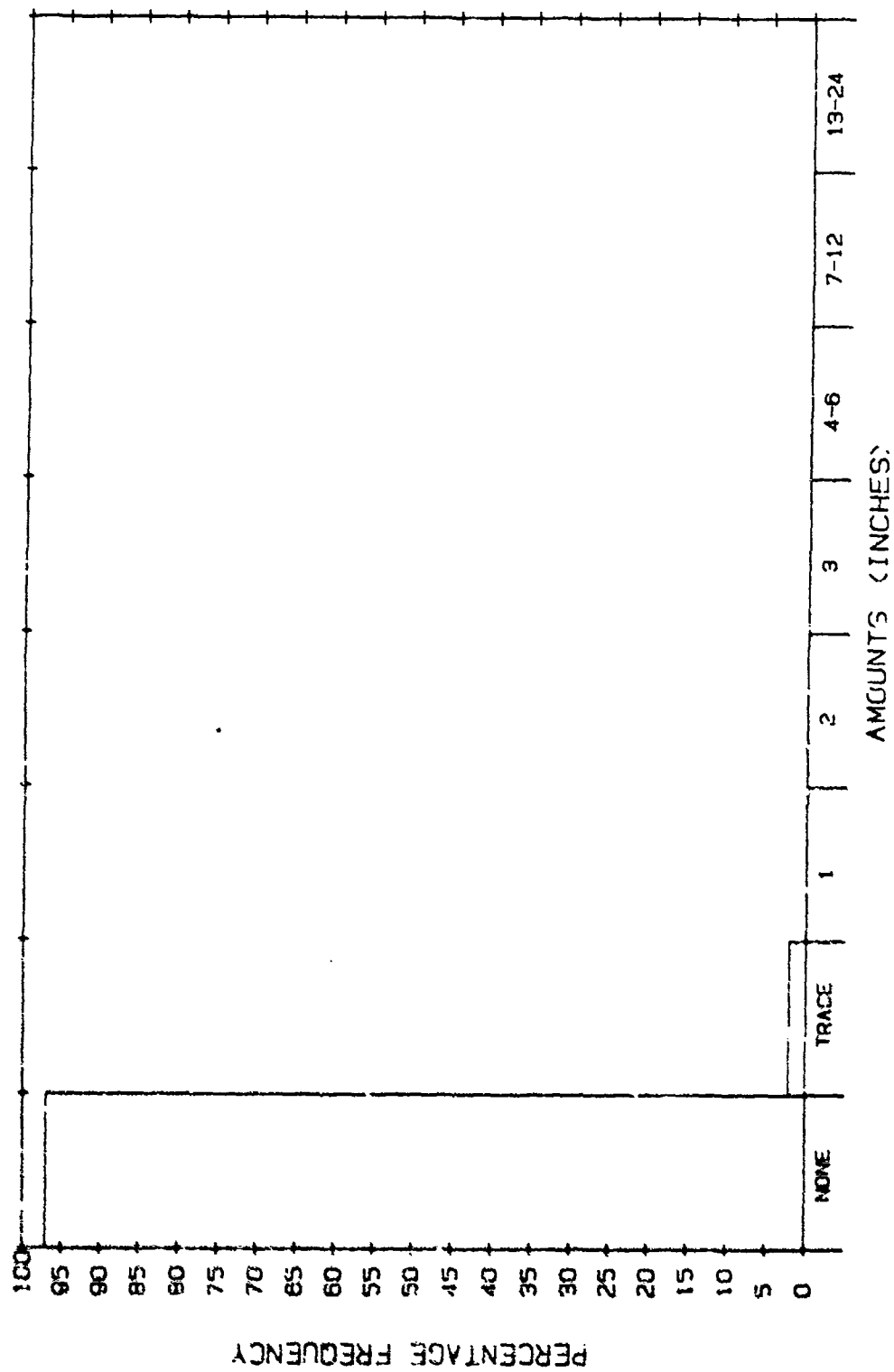


Figure A-157. Daily Amounts of Snowdepth, Mean of Korean Airbases in March.

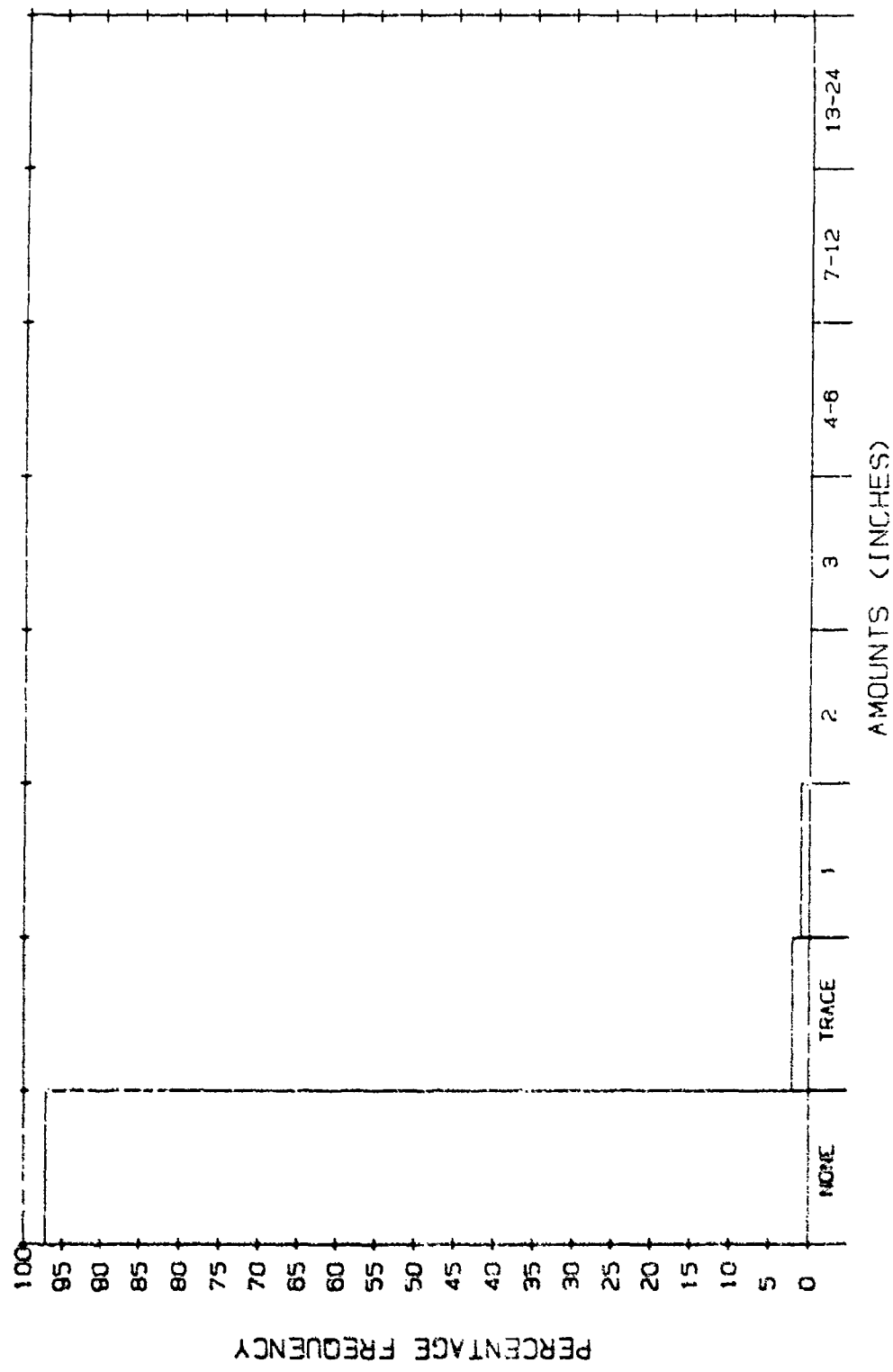


Figure A-158. Daily Amounts of Snowdepth, Mean of Korean Airbases in November.

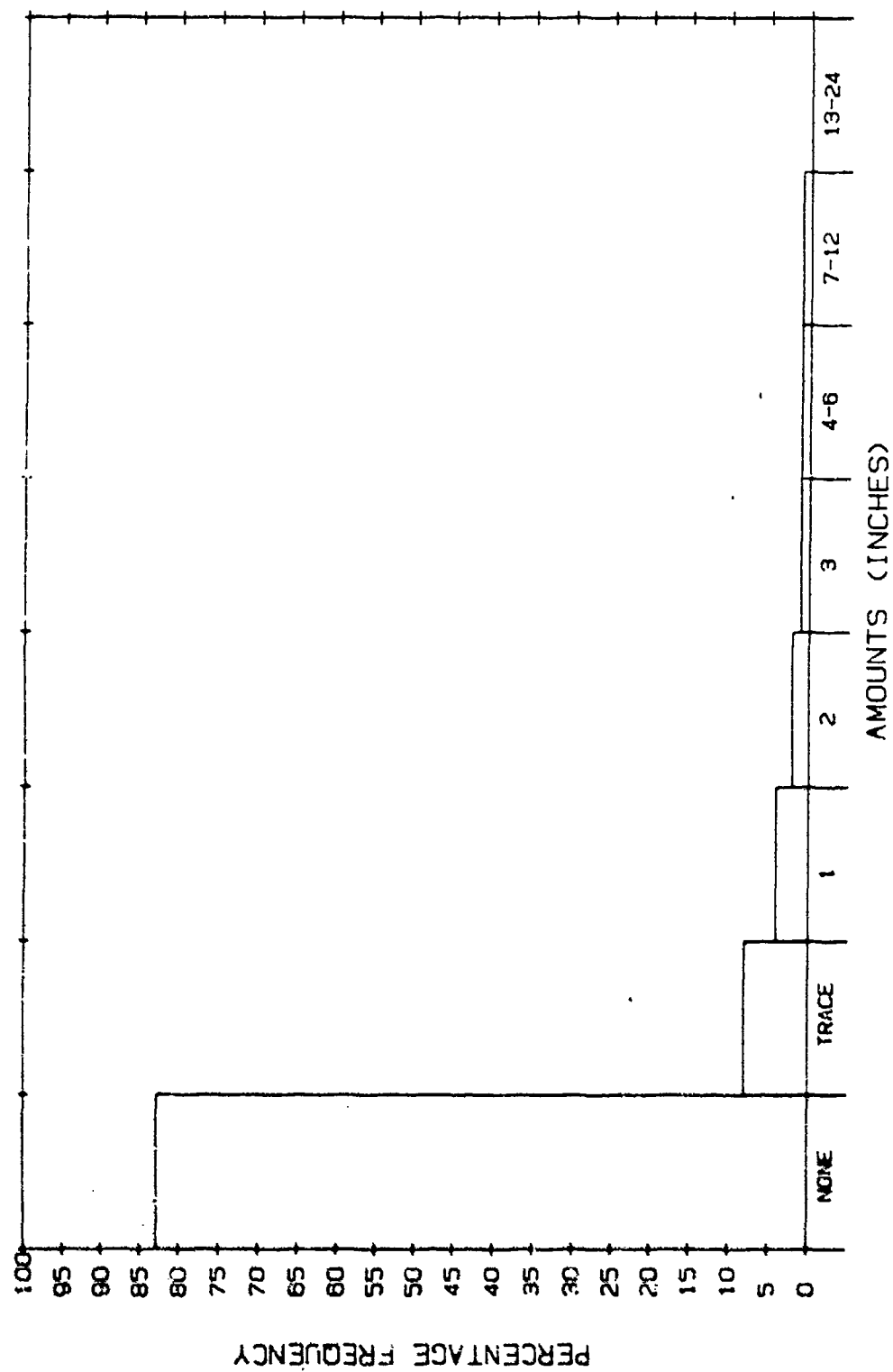


Figure A-159. Daily Amounts of Snowdepth, Mean of Korean Airbases in December.

d. Frequency of Occurrence of Weather Conditions

These graphs break down the occurrence of precipitation into observations of rain, freezing rain, snow or thunderstorms. For each base and each month, the percent of total observations that record each type of precipitation is calculated. These percentages are averaged across all bases in the theater to produce the frequency of occurrence for the theater. The worst case is considered to be the maximum frequency of occurrence of each type of precipitation across the theater. Again, inconsistency occurs since more than one condition is sometimes recorded during the same observation.

EXAMPLE: Consider the German theater in January (Figure A-161). For the mean of the German airbases during this month, approximately 1 percent of the observations record freezing rain/drizzle; snow/sleet is observed 9 percent of the time; and rain occurs in 15 percent of the monthly observations.

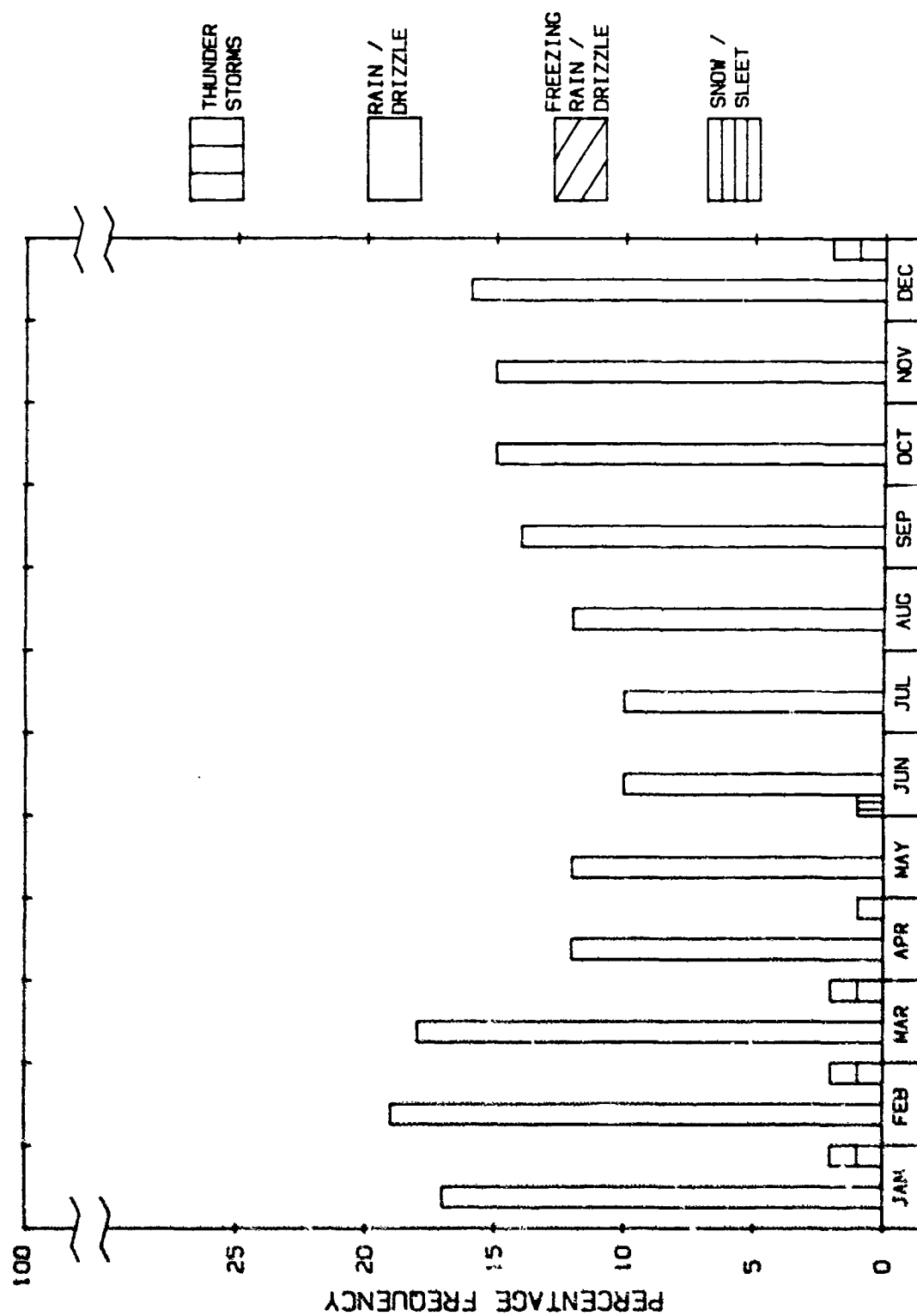


Figure A-160. Frequency of Occurrence of Weather Conditions, Upper Heyford.

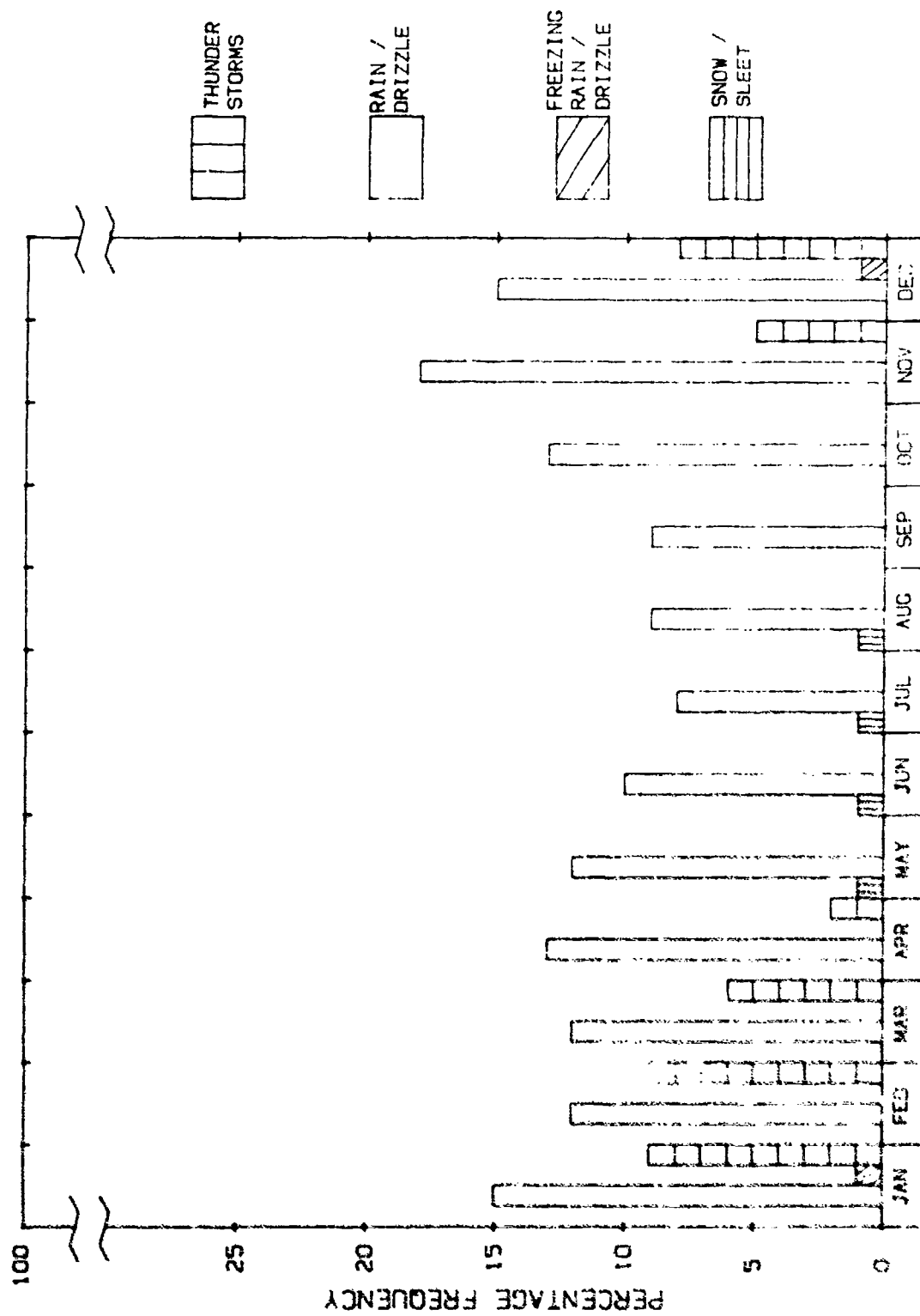


Figure A-161. Frequency of Occurrence of Weather Conditions, Mean of German Airbases.

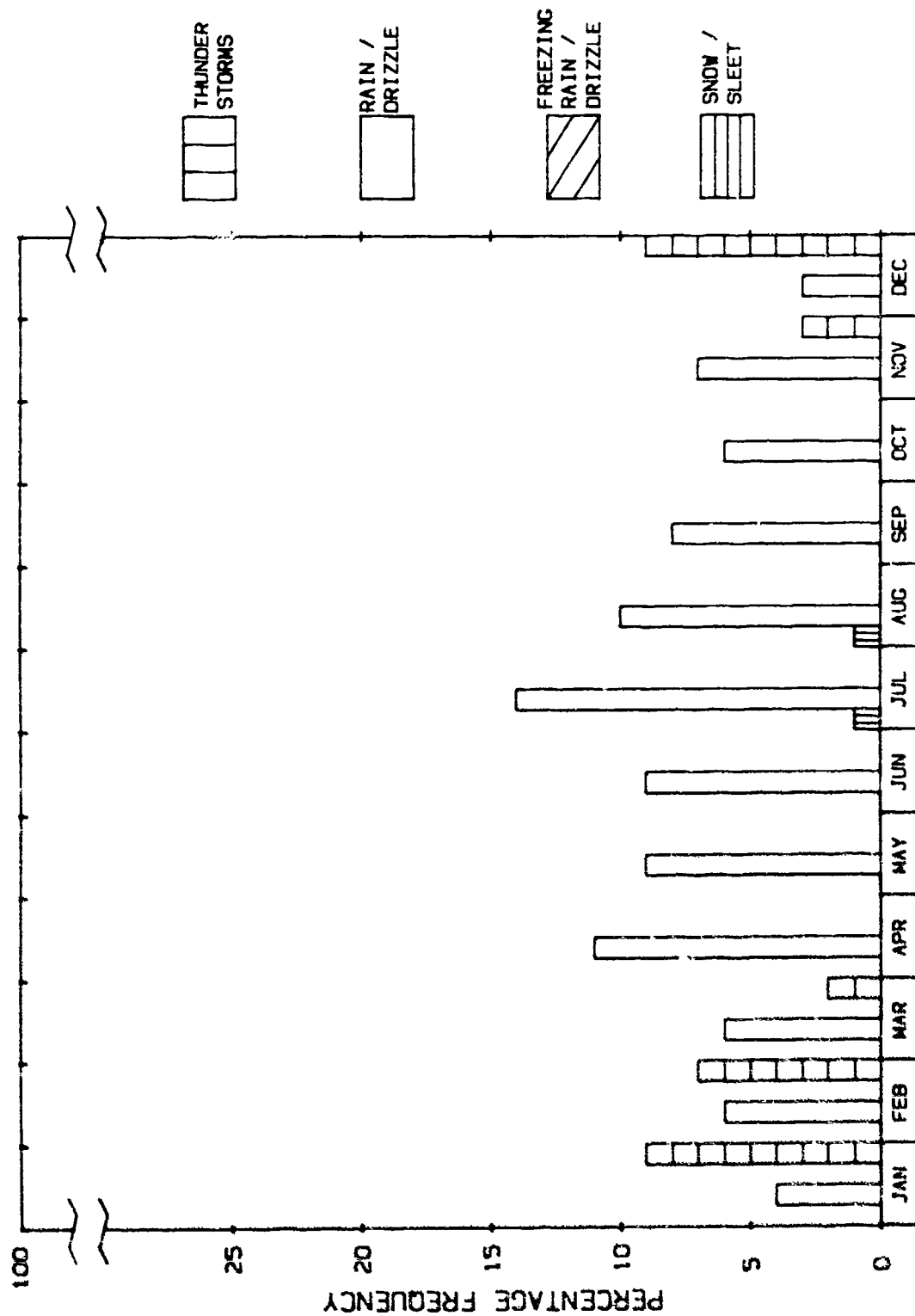


Figure A-162. Frequency of Occurrence of Weather Conditions, Mean of Korean Airbases.

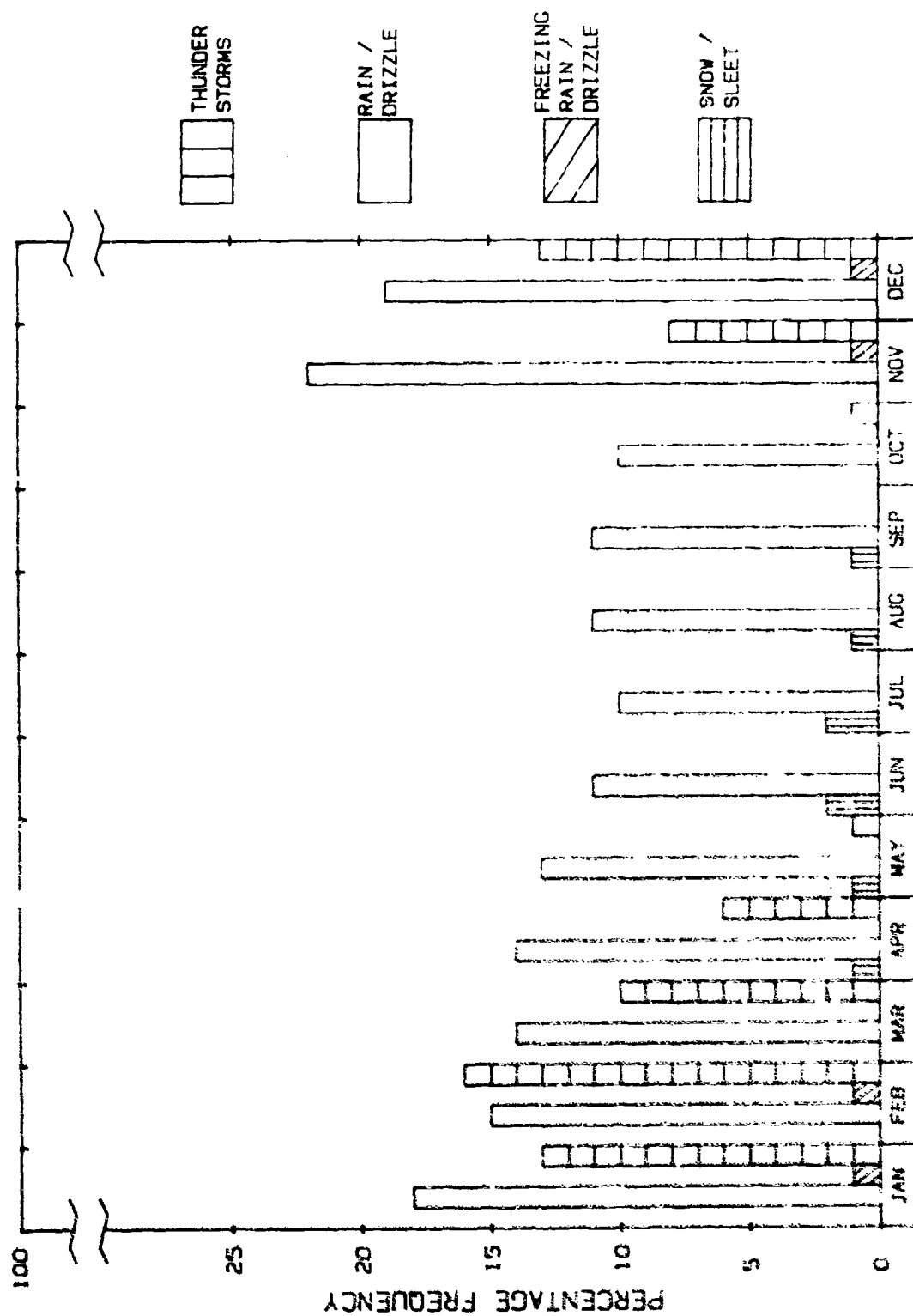


Figure A-163. Frequency of Occurrence of Weather Conditions, Worst Case: Germany.

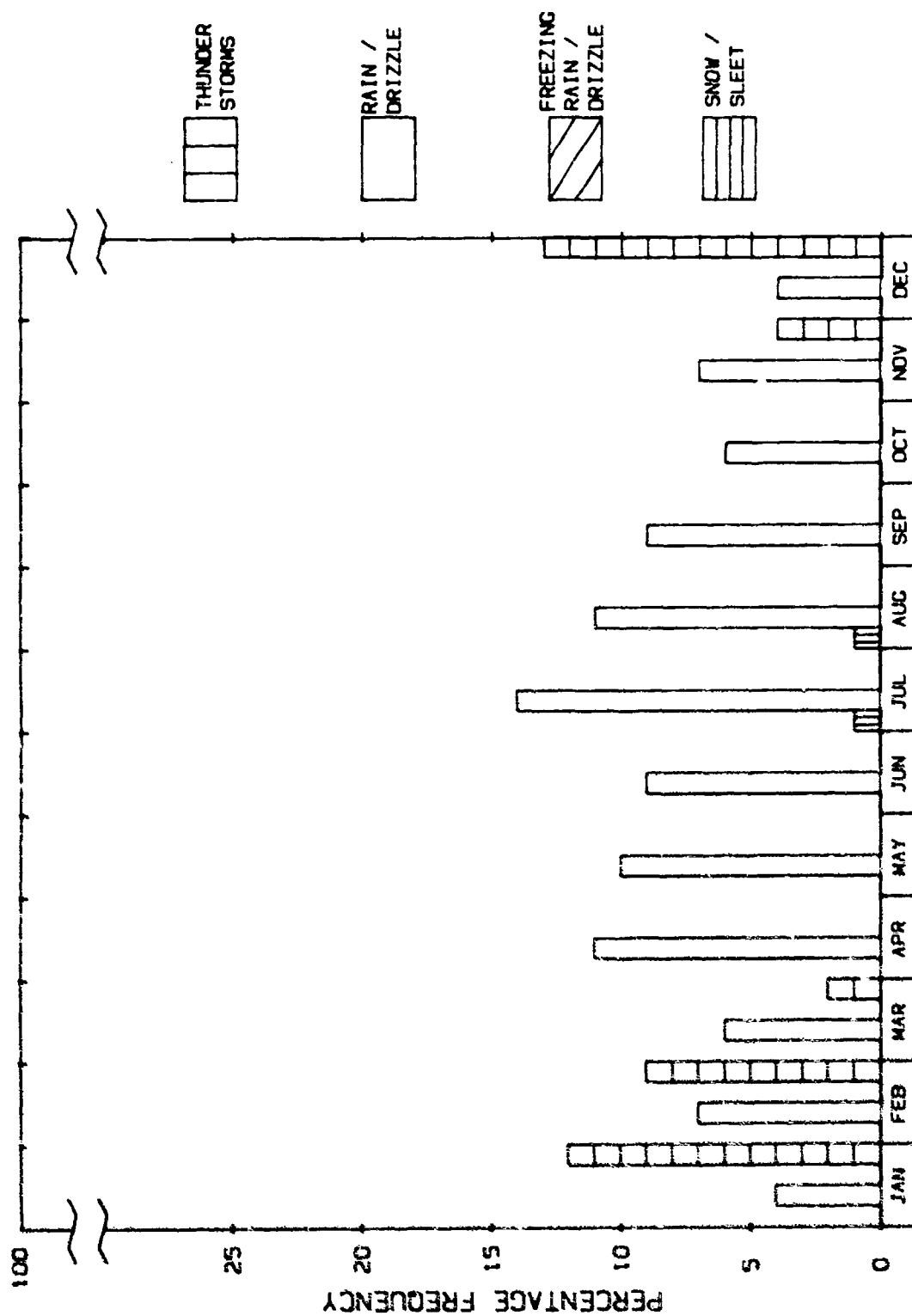


Figure A-164. Frequency of Occurrence of Weather Conditions, Worst Case: Korea.

e. Maximum Amounts of Precipitation

Table A-2 represents maximum intensity rainfall and snowfall by country as compiled by ETAC. Note that this table indicates nothing about the frequency of occurrence of these events. The data represent the greatest amount recorded for each indicated duration.

EXAMPLE: The table shows that for a storm lasting 4 hours in Korea, 10.5 inches of rainfall are the greatest amount observed to date.

TABLE A-2. MAXIMUM AMOUNTS OF PRECIPITATION - WORST CASE

	UPPER HEYFORD	GERMANY	KOREA
MAX 1/2-HOUR RAINFALL	2.5"	2.1"	4.8"
1-HOUR RAINFALL	2.9"	2.5"	5.6"
2-HOUR RAINFALL	4.1"	3.5"	7.9"
4-HOUR RAINFALL	5.5"	4.7"	10.5"
6-HOUR RAINFALL	8.6"	5.6"	12.5"
MAX 2-HOUR SNOWFALL	7.1"	21.6"	22.8"
4-HOUR SNOWFALL	8.4"	25.9"	27.3"
6-HOUR SNOWFALL	9.3"	28.6"	30.1"

f. Duration of Precipitation

These sets of graphs represent the conditional duration of any kind of precipitation. That is, the data show the number of hours that precipitation lasts, given that it occurs.

Recall that these are produced from hourly observations. Thus, if the duration of precipitation is 2 hours, it could have been raining for 120 minutes or it could have rained only 5 minutes in each hour. A long period of record is required to avoid obvious problems.

These statistics were derived by considering the ratio of the unconditional duration of precipitation to the percent of time that any precipitation observations were made. In computing these values, some round-off error was likely to occur within each time interval. This error could be as great as $.5 \times (\text{Number of Intervals})$ if each had a decimal portion of .5 and had been rounded up. Furthermore, the percentages for each interval were averaged across the theater. Thus, even though these represent exclusive events, the total percent of occurrence may not sum to 100 percent.

EXAMPLE: Consider Upper Heyford in January (Figure A-165). In approximately 27 percent of the observations that recorded precipitation during this month, the precipitation lasted less than 1 hour. Precipitation lasted from 7 to 8 hours in 4 percent of the observations of precipitation.

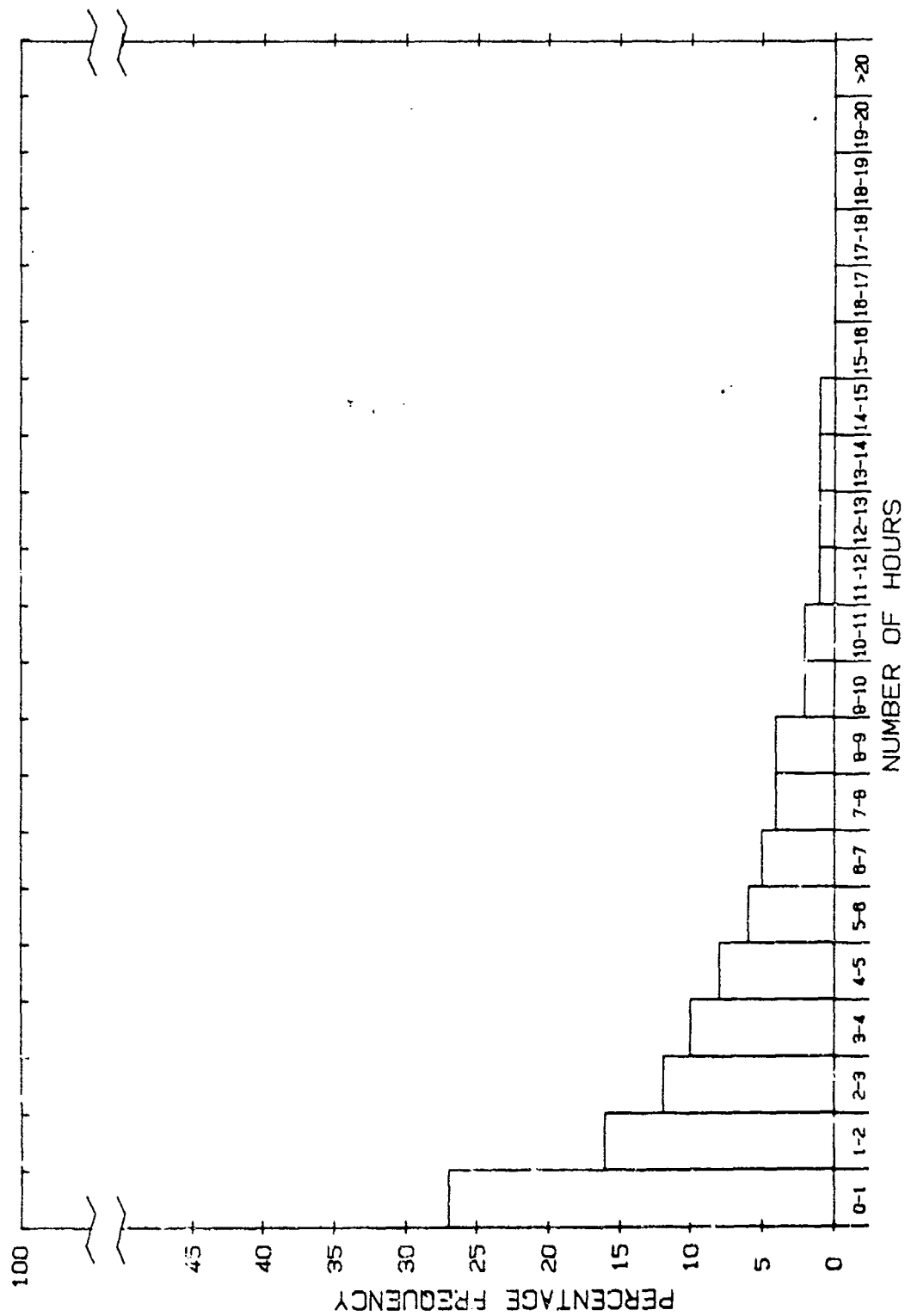


Figure A-165. Duration of Precipitation, Upper Heyford - January.

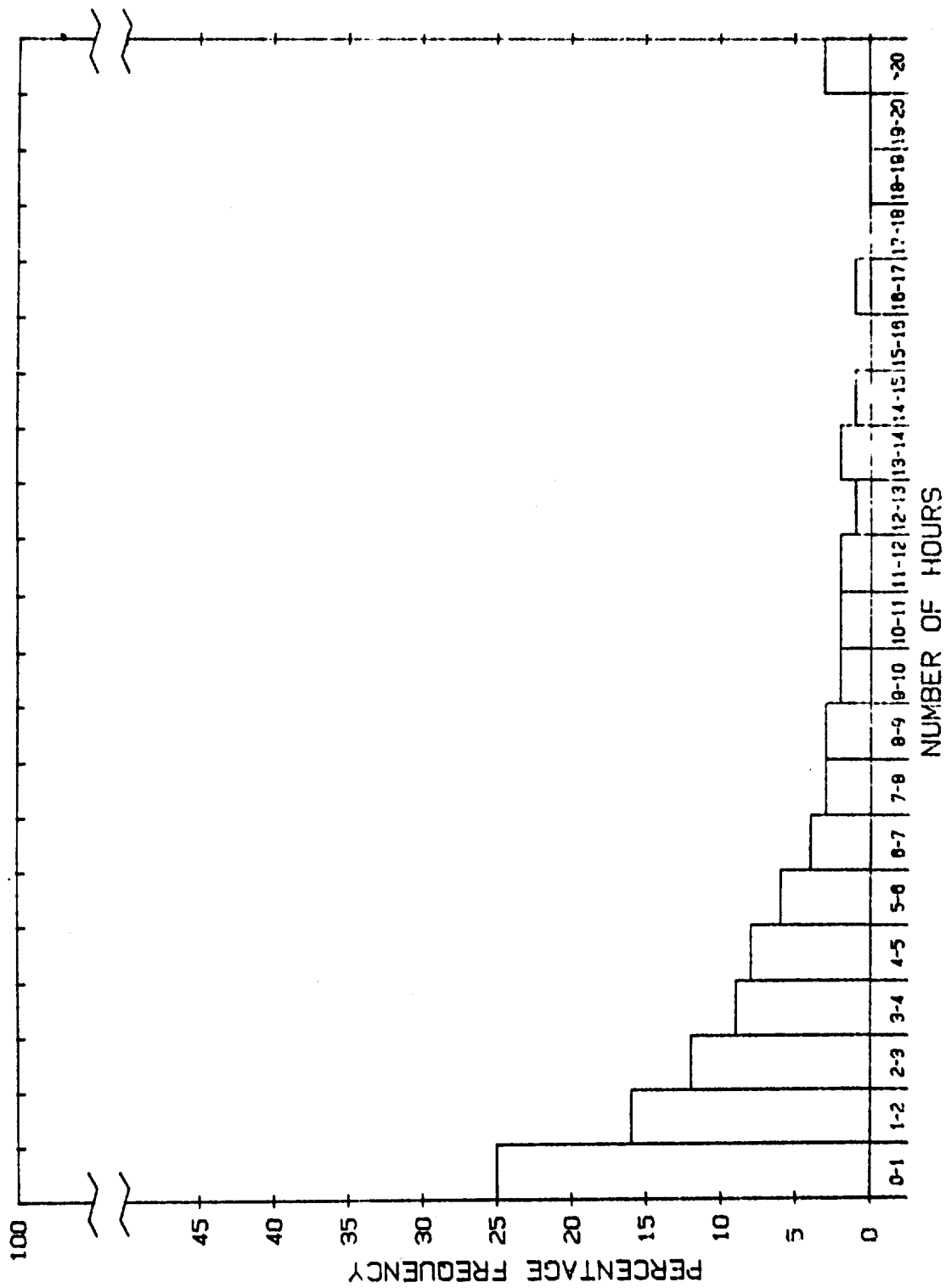


Figure A-166. Duration of Precipitation, Upper Heyford - February.

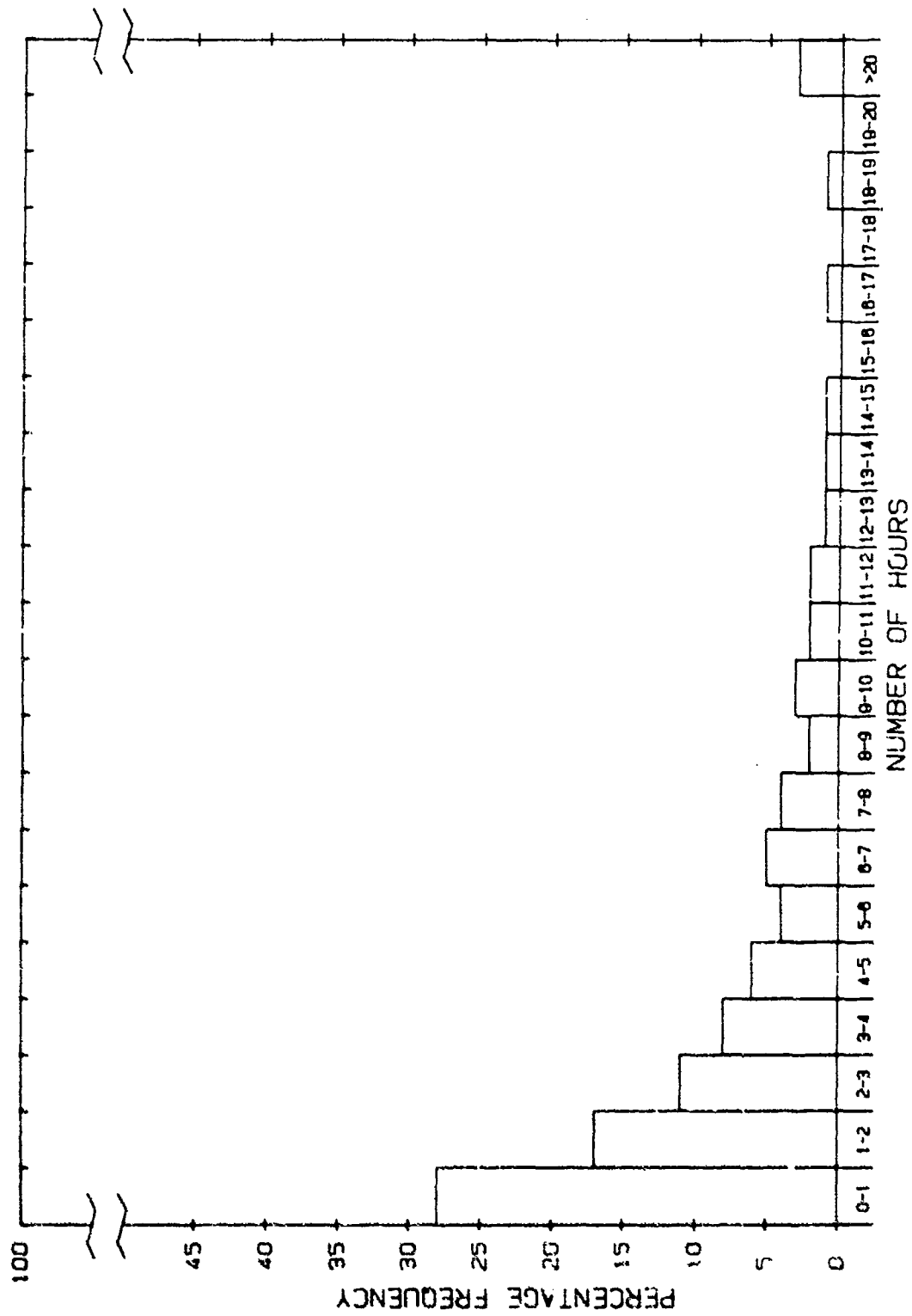


Figure A-167. Duration of Precipitation, Upper Heyford - March.

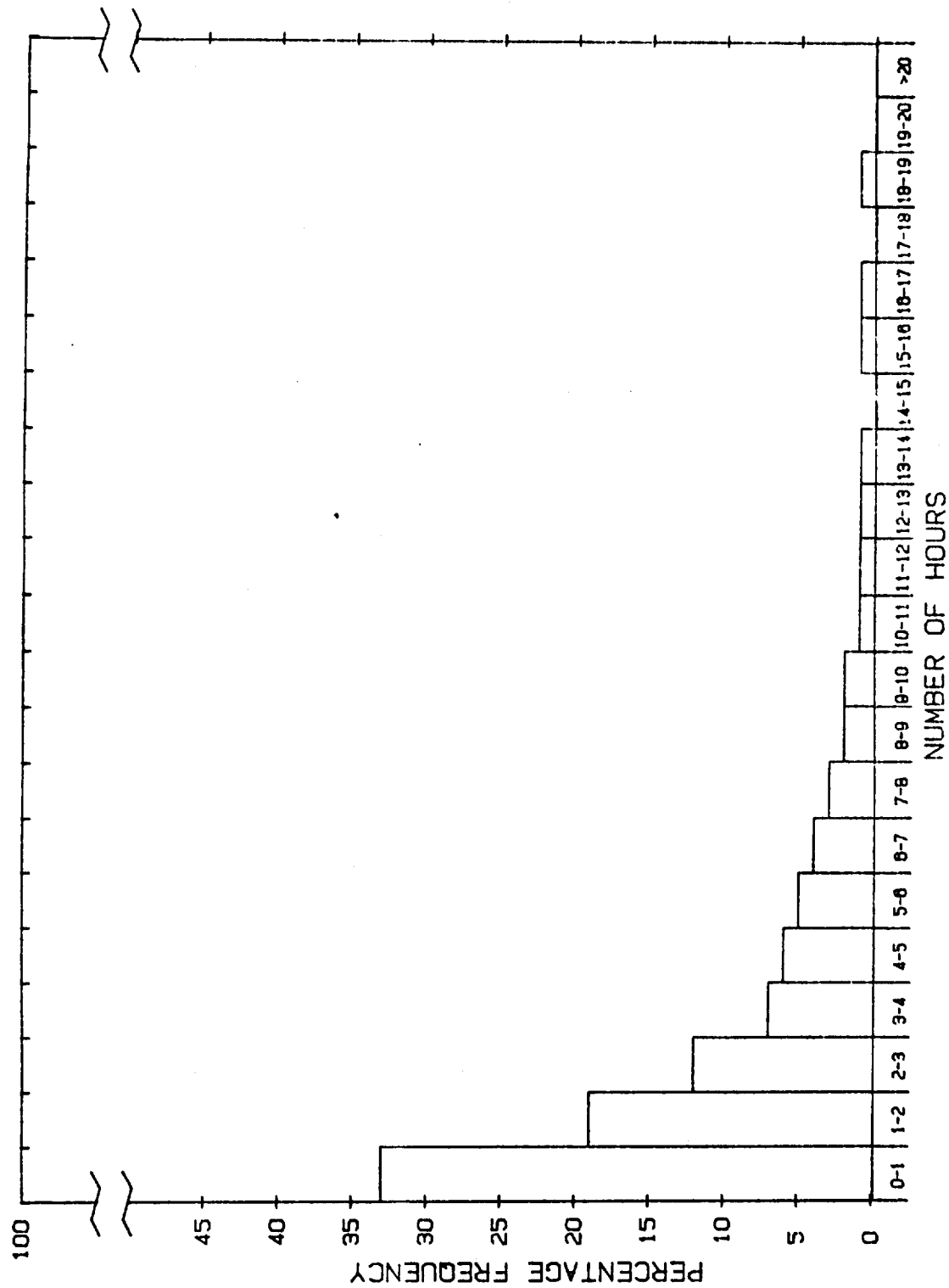


Figure A-168. Duration of Precipitation, Upper Heyford - April.

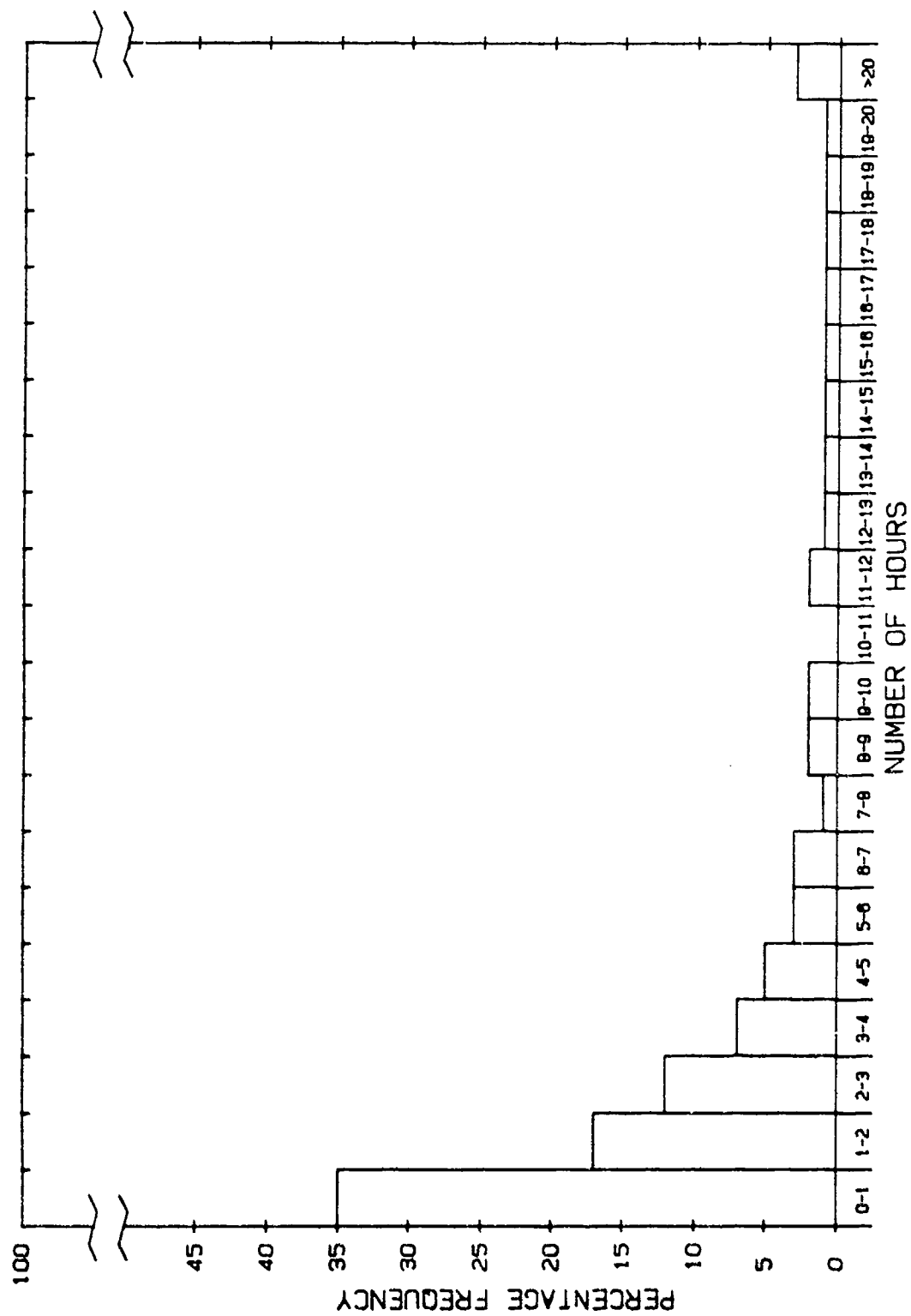


Figure A-169. Duration of Precipitation, Upper Heyford - May.

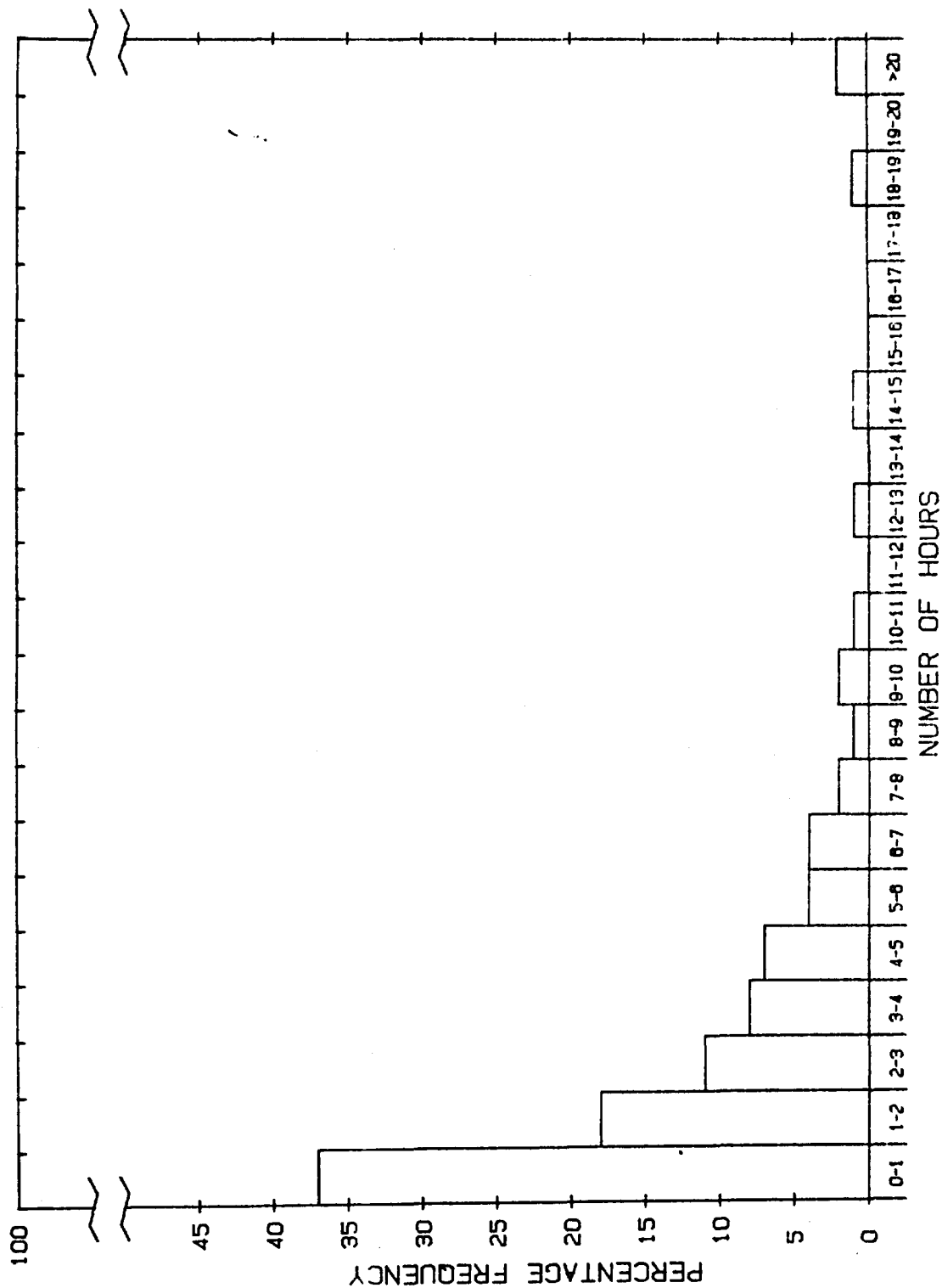


Figure A-170. Duration of Precipitation, Upper Heyford - June.

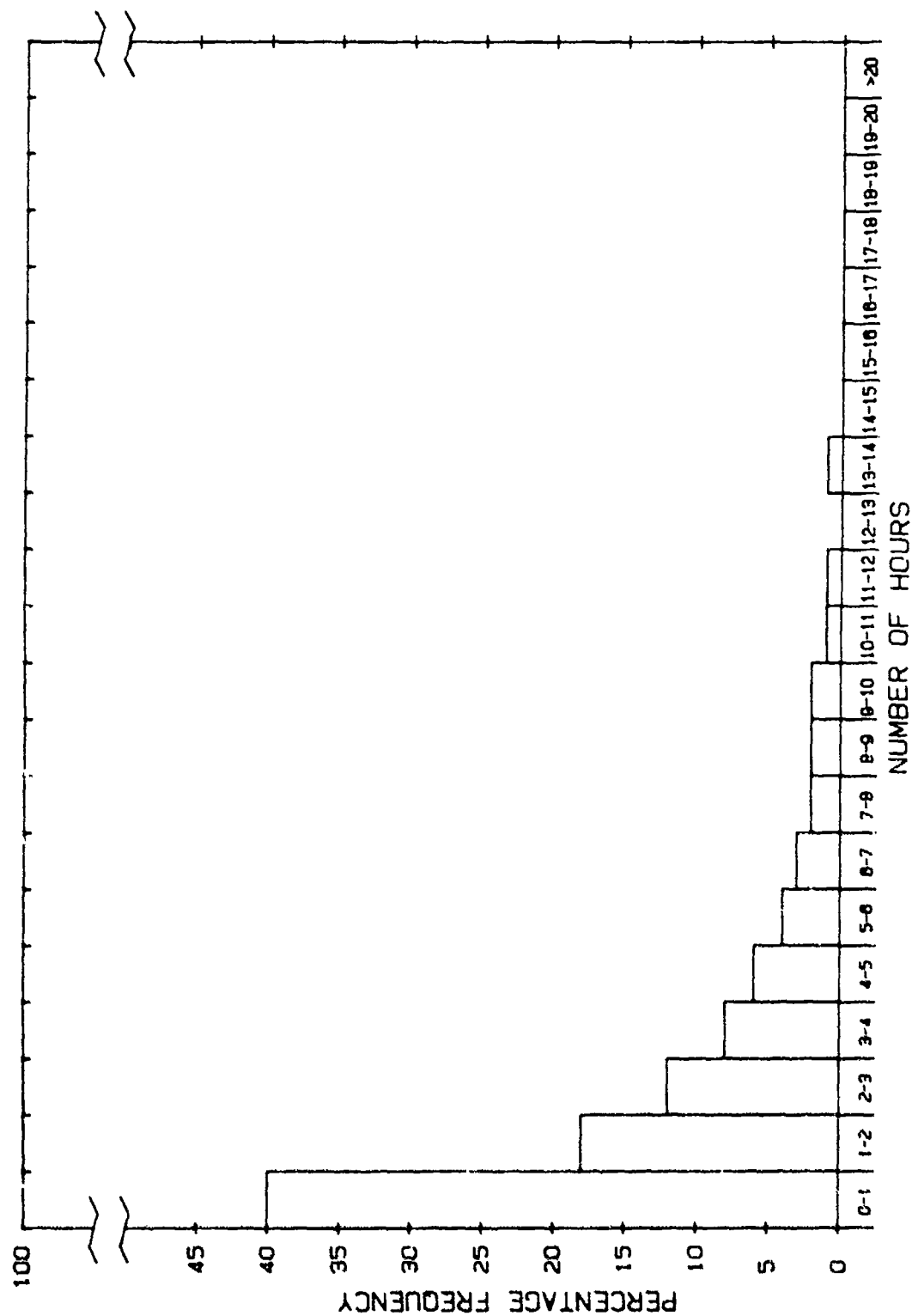


Figure A-171. Duration of Precipitation, Upper Heyford - July.

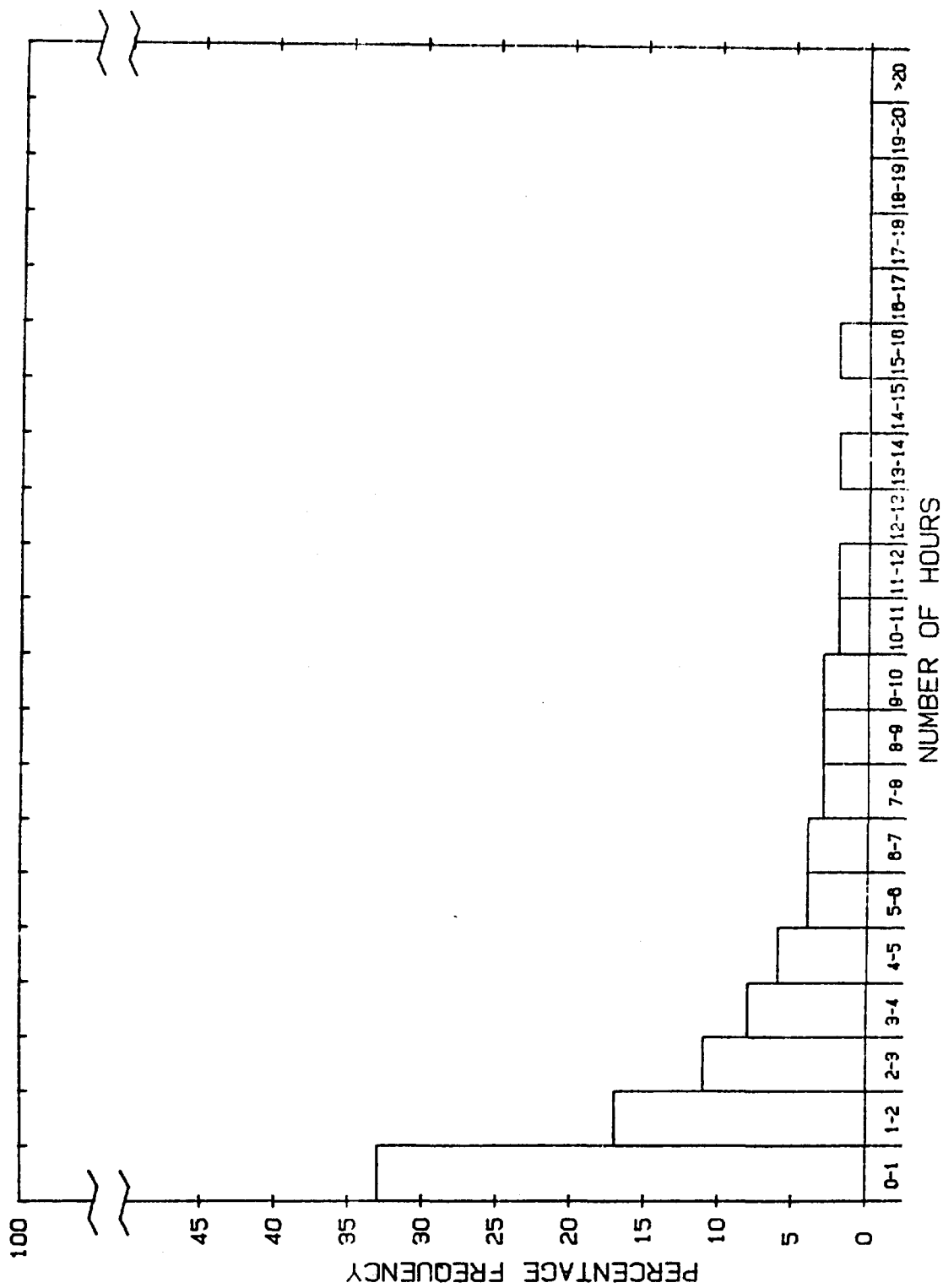


Figure A-172. Duration of Precipitation, Upper Heyford - August.

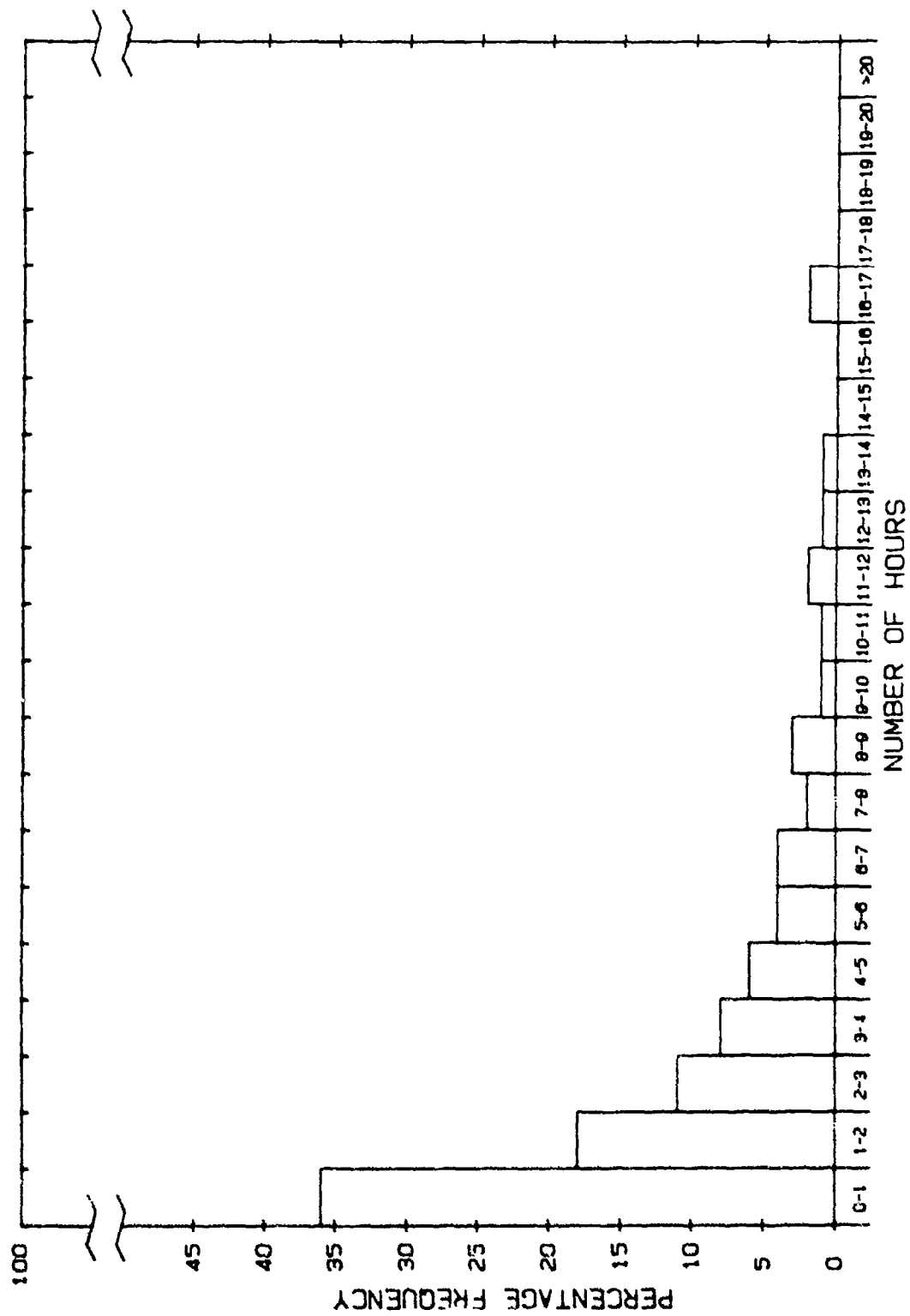


Figure A-173. Duration of Precipitation, Upper Heyford - September.

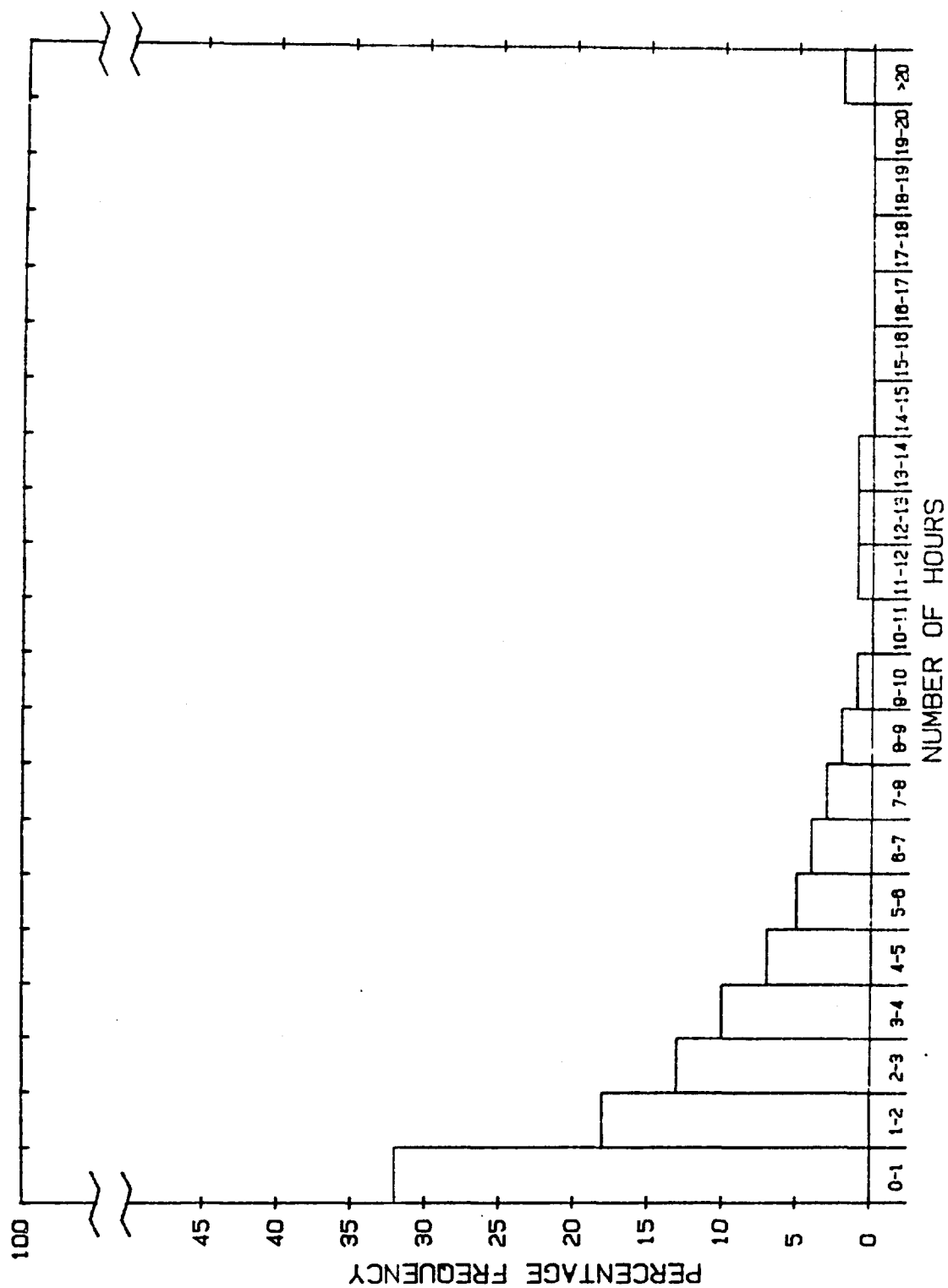


Figure A-174. Duration of Precipitation, Upper Heyford - October.

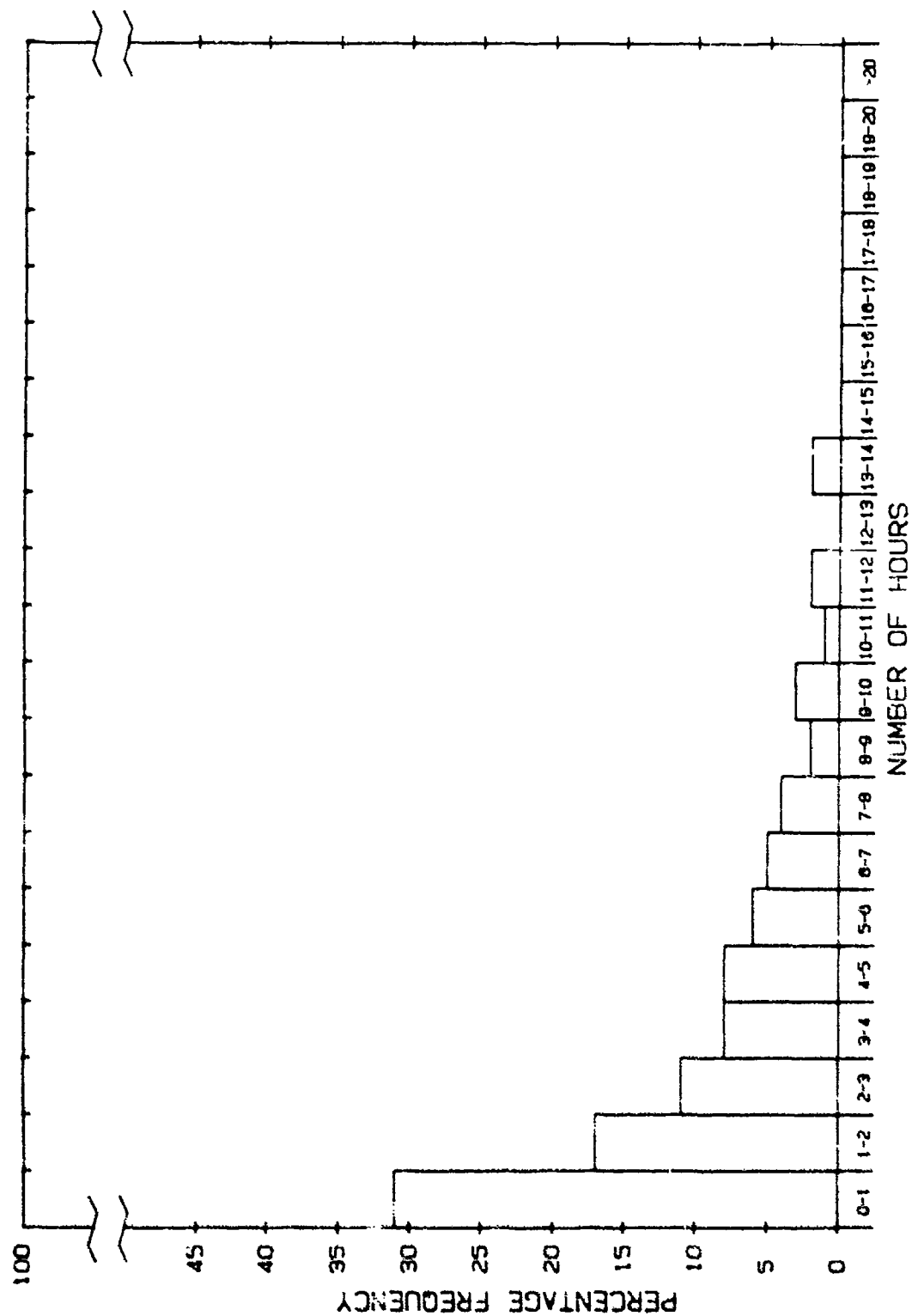


Figure A-175. Duration of Precipitation, Upper Heyford - November.

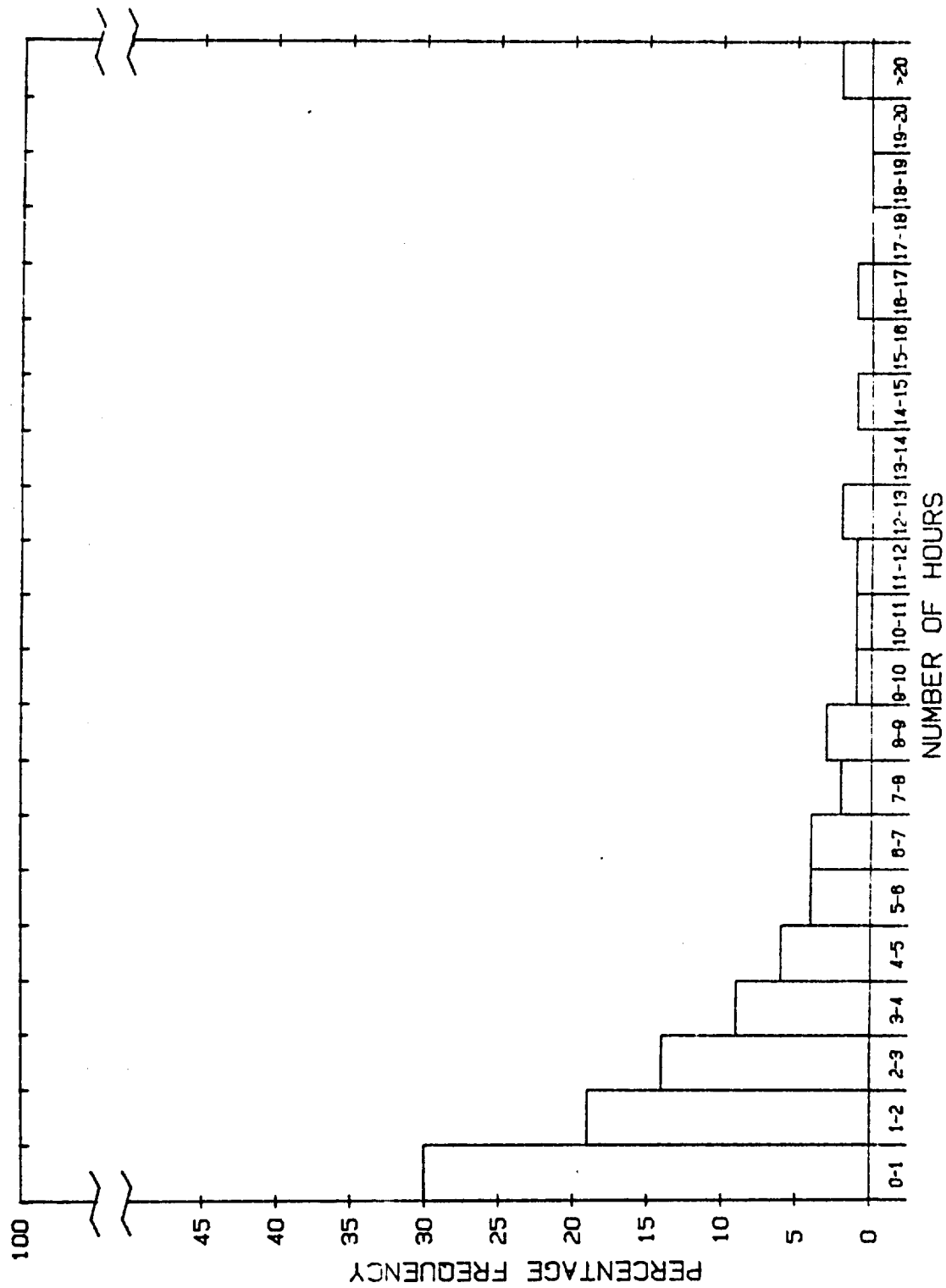


Figure A-176. Duration of Precipitation, Upper Heyford - December.

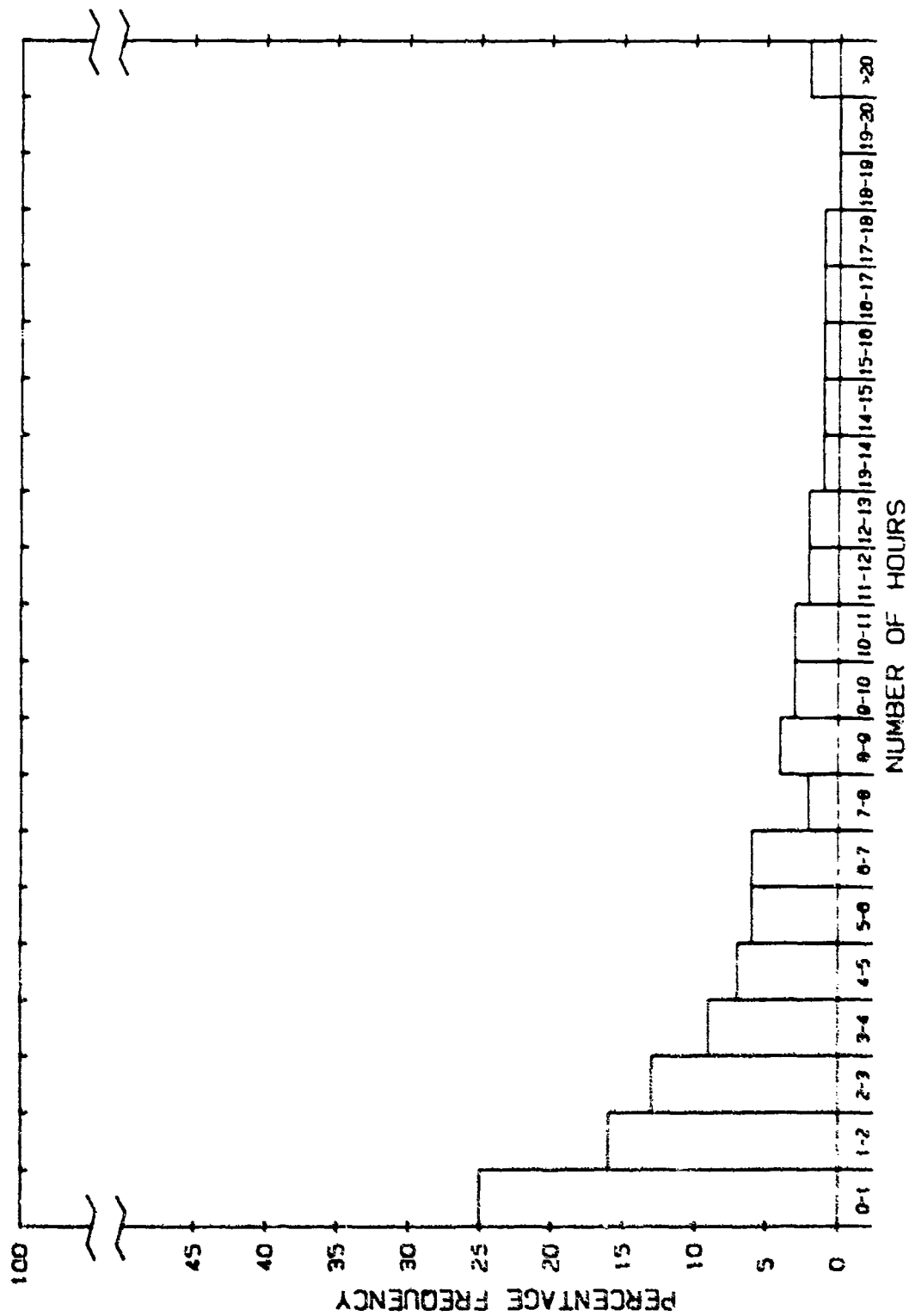


Figure A-177. Duration of Precipitation, Mean of German Airbases - January.

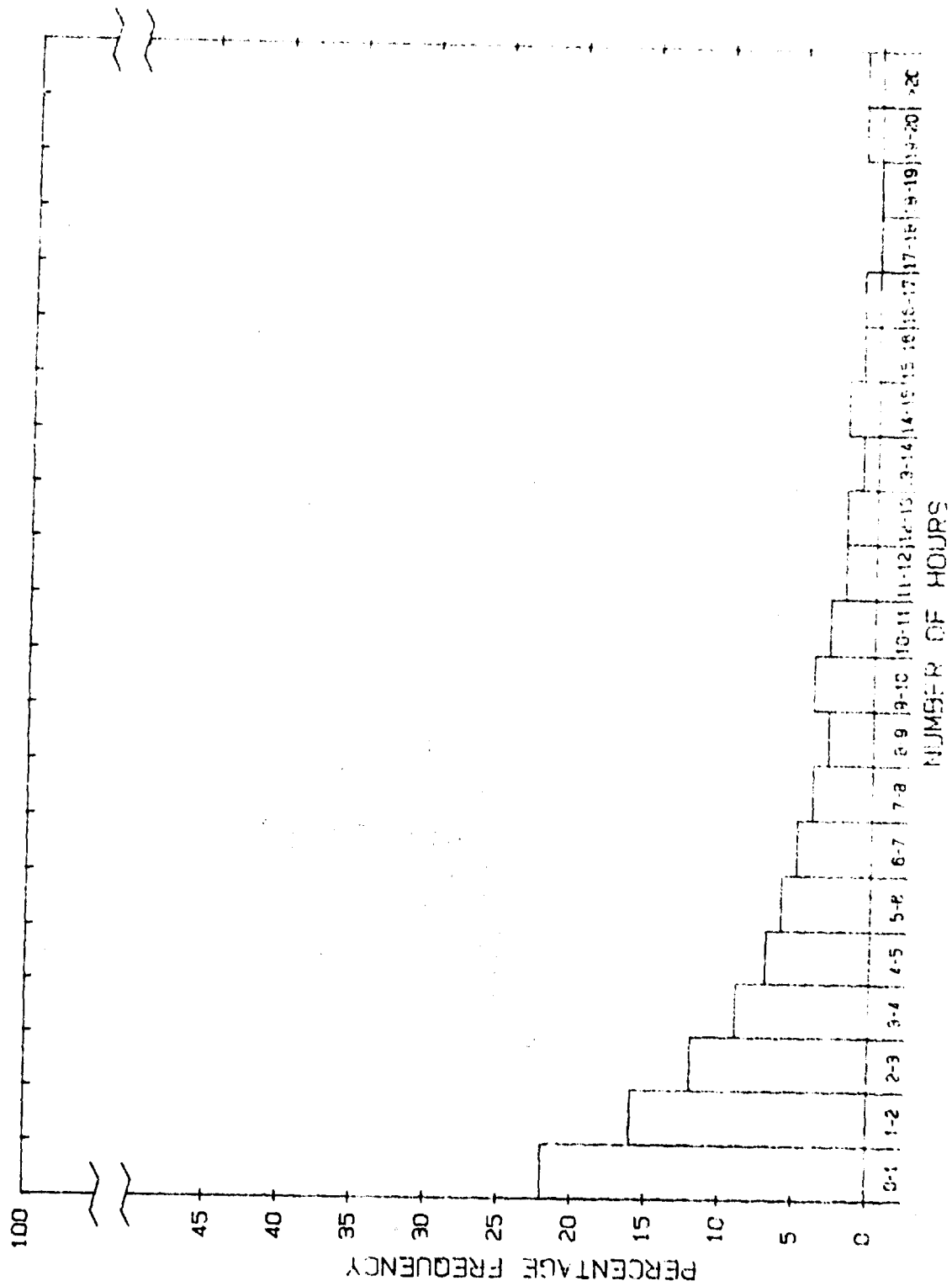


Figure A-178. Duration of Precipitation, Mean of German Airbases - February.

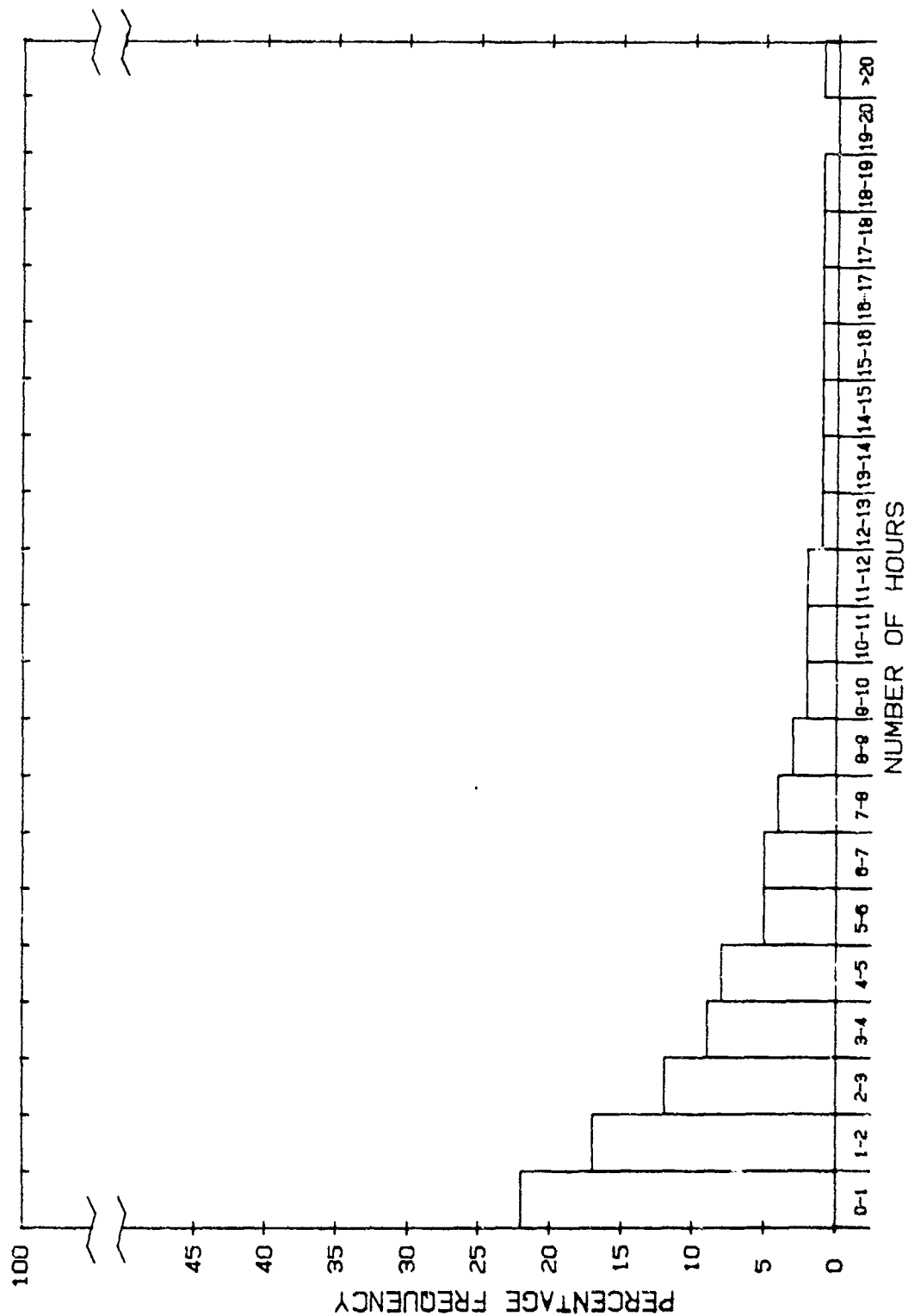


Figure A-179. Duration of Precipitation, Mean of German Airbuses - March.

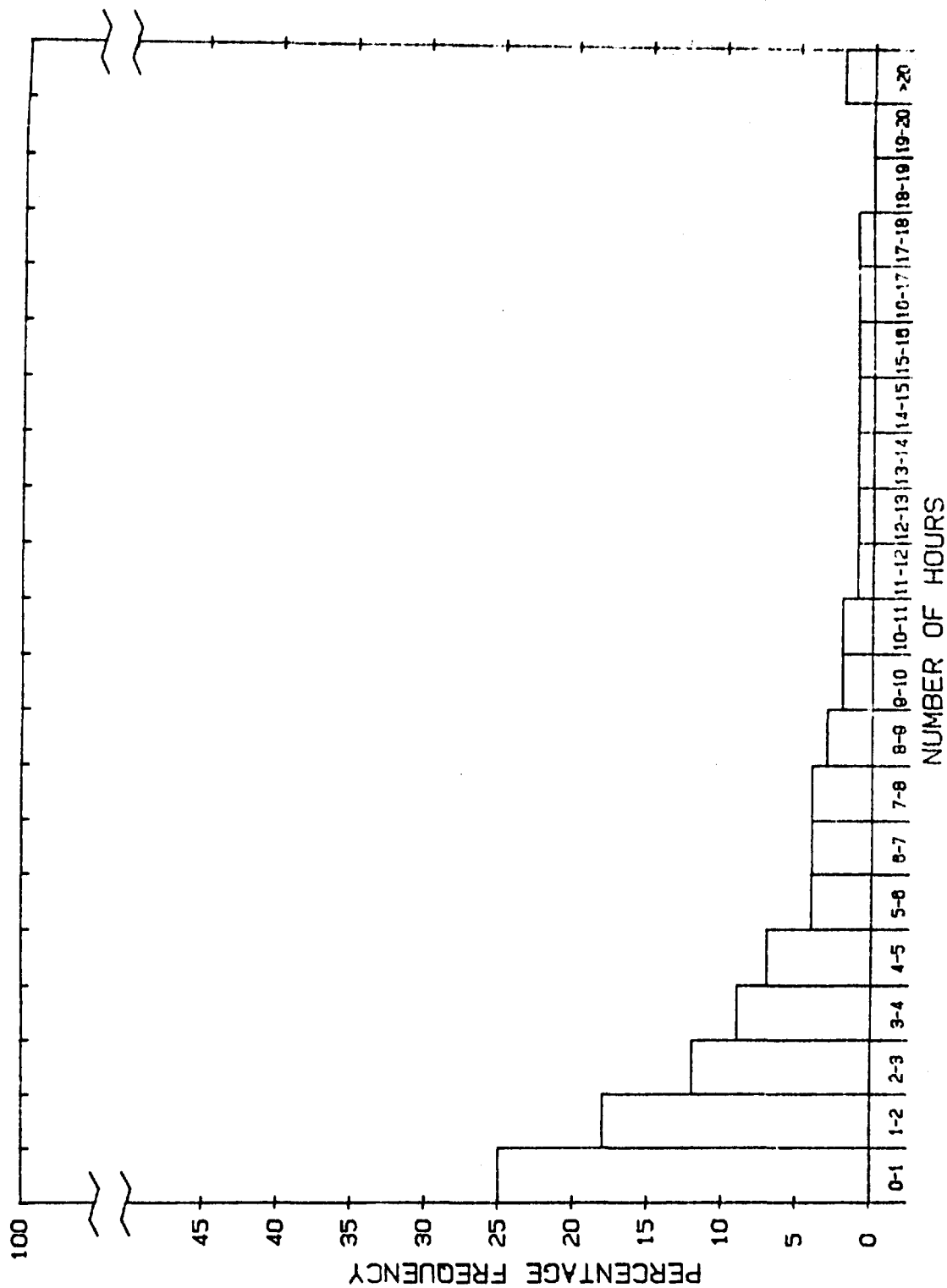


Figure A-180. Duration of Precipitation, Mean of German Airbases - April.

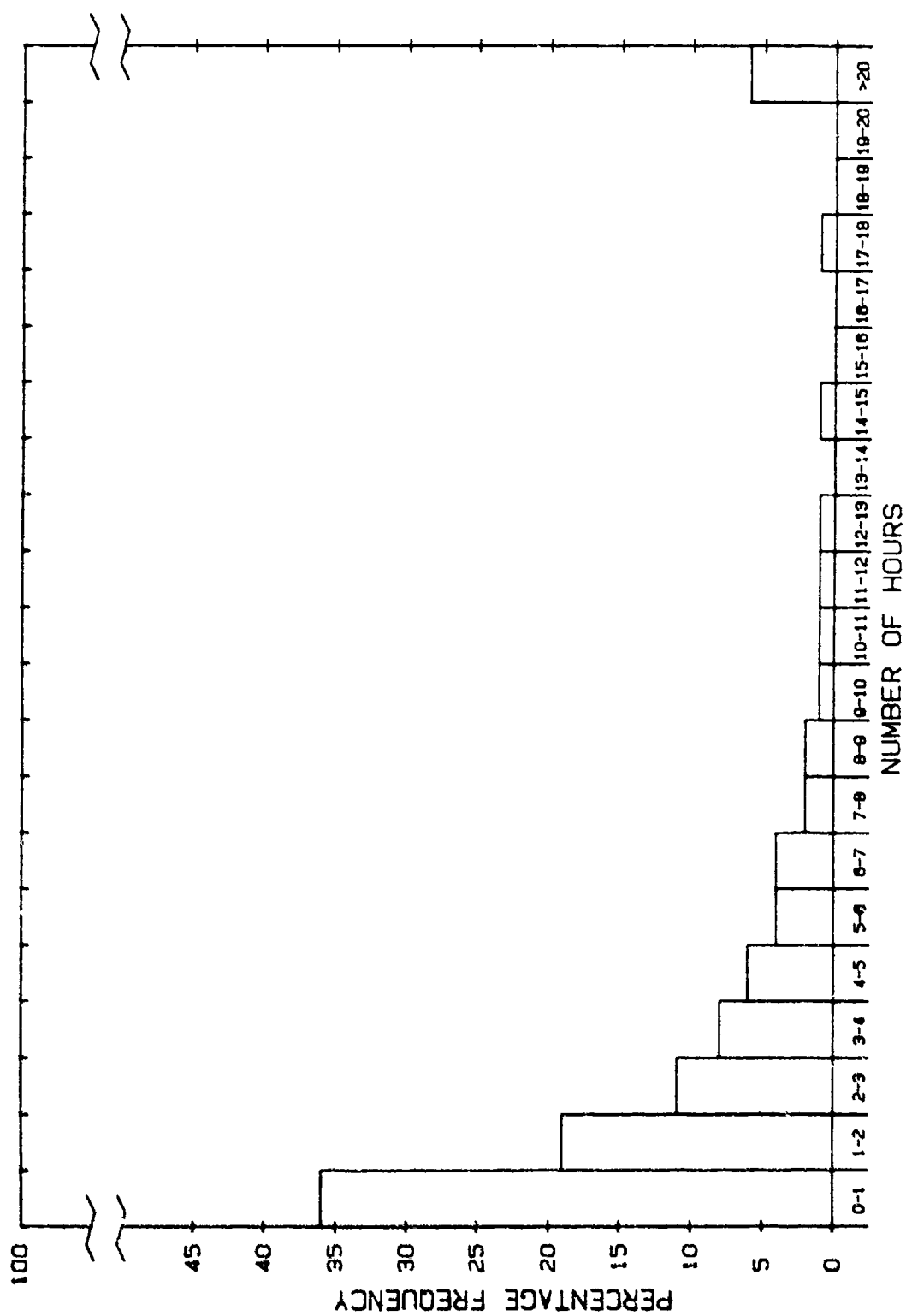


Figure A-181. Duration of Precipitation, Mean of German Airbases - May.

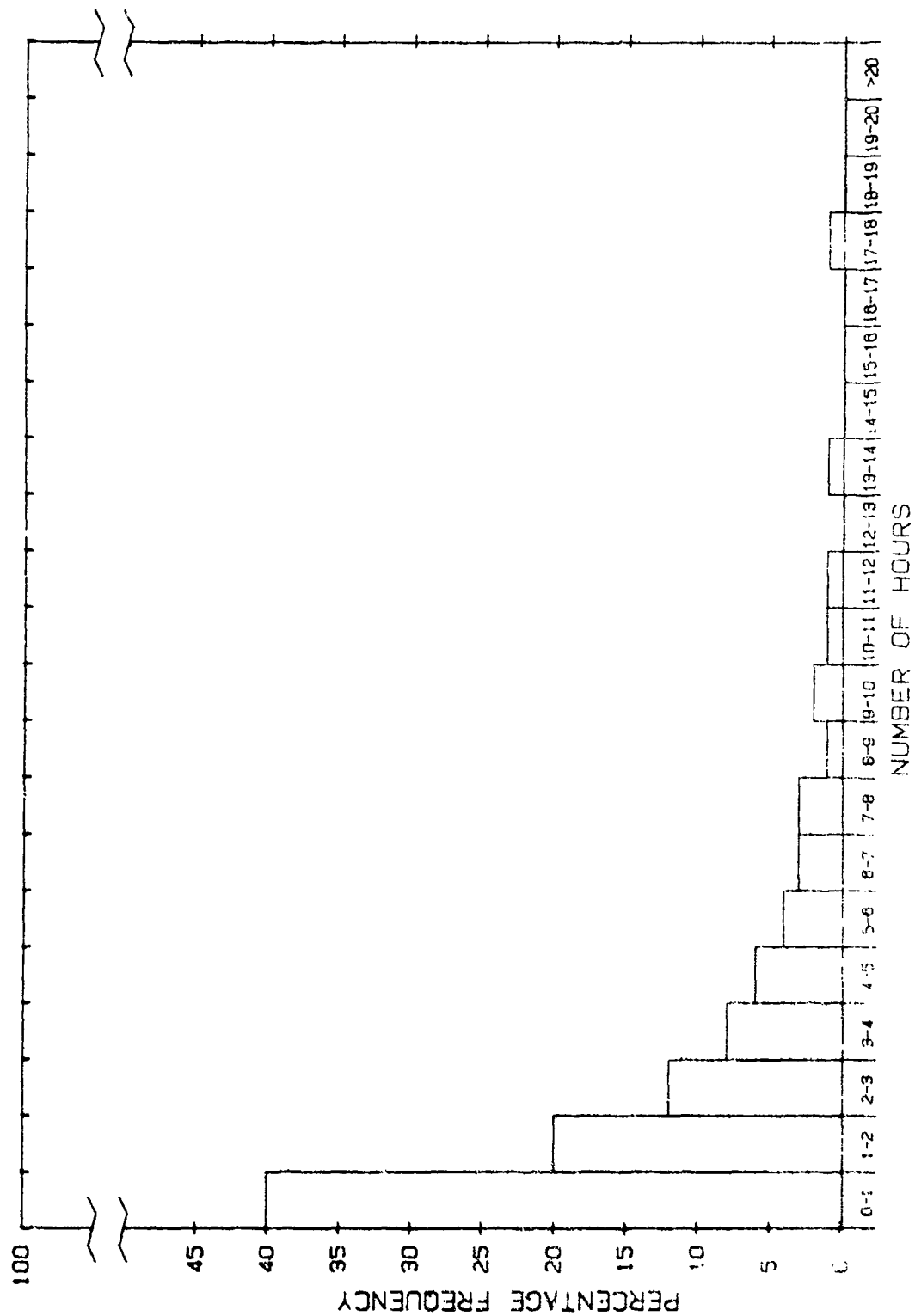


Figure A-182. Duration of Precipitation, Mean of German Airbases - June.

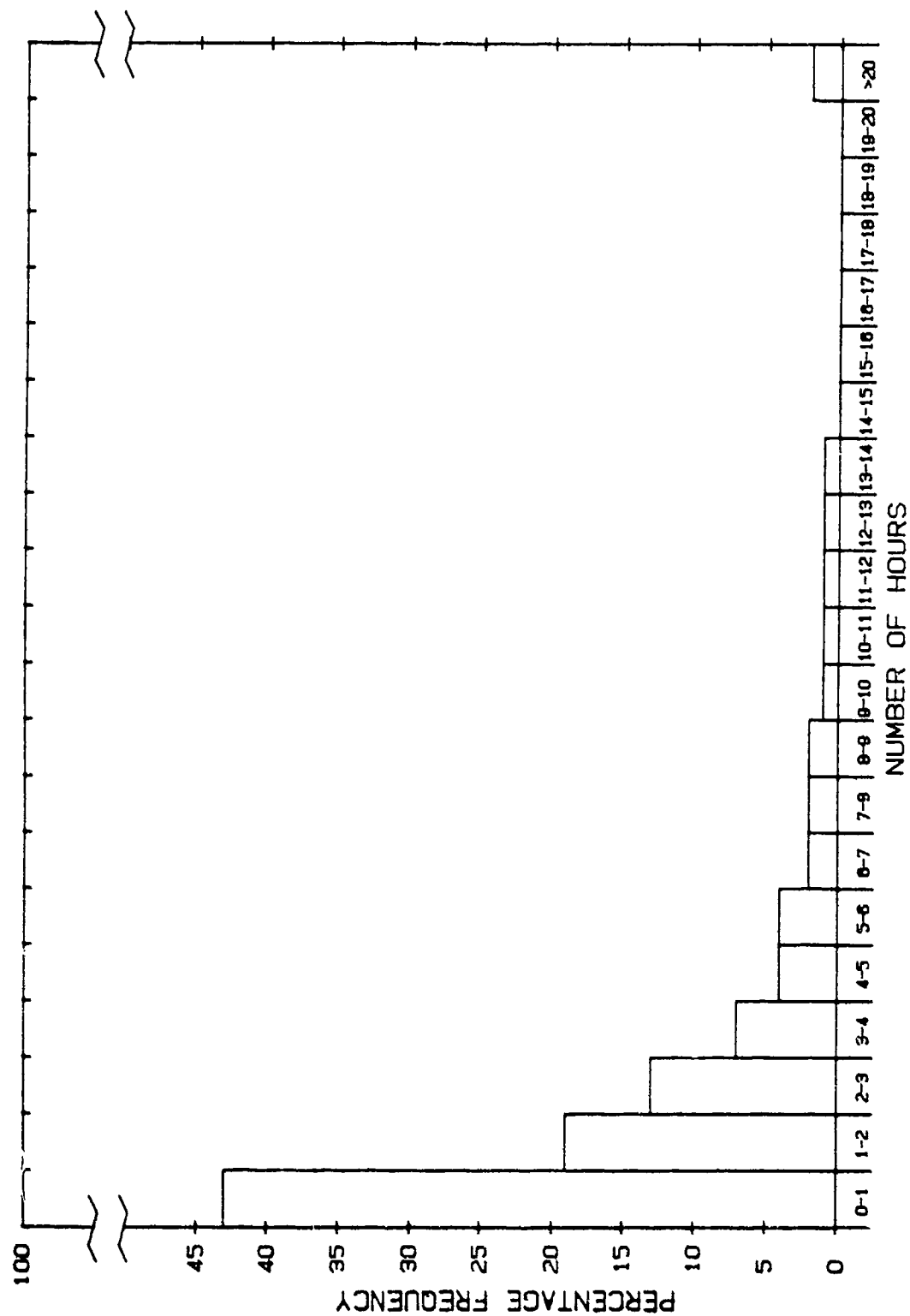


Figure A-163. Duration of Precipitation, Mean of German Airbases - July.

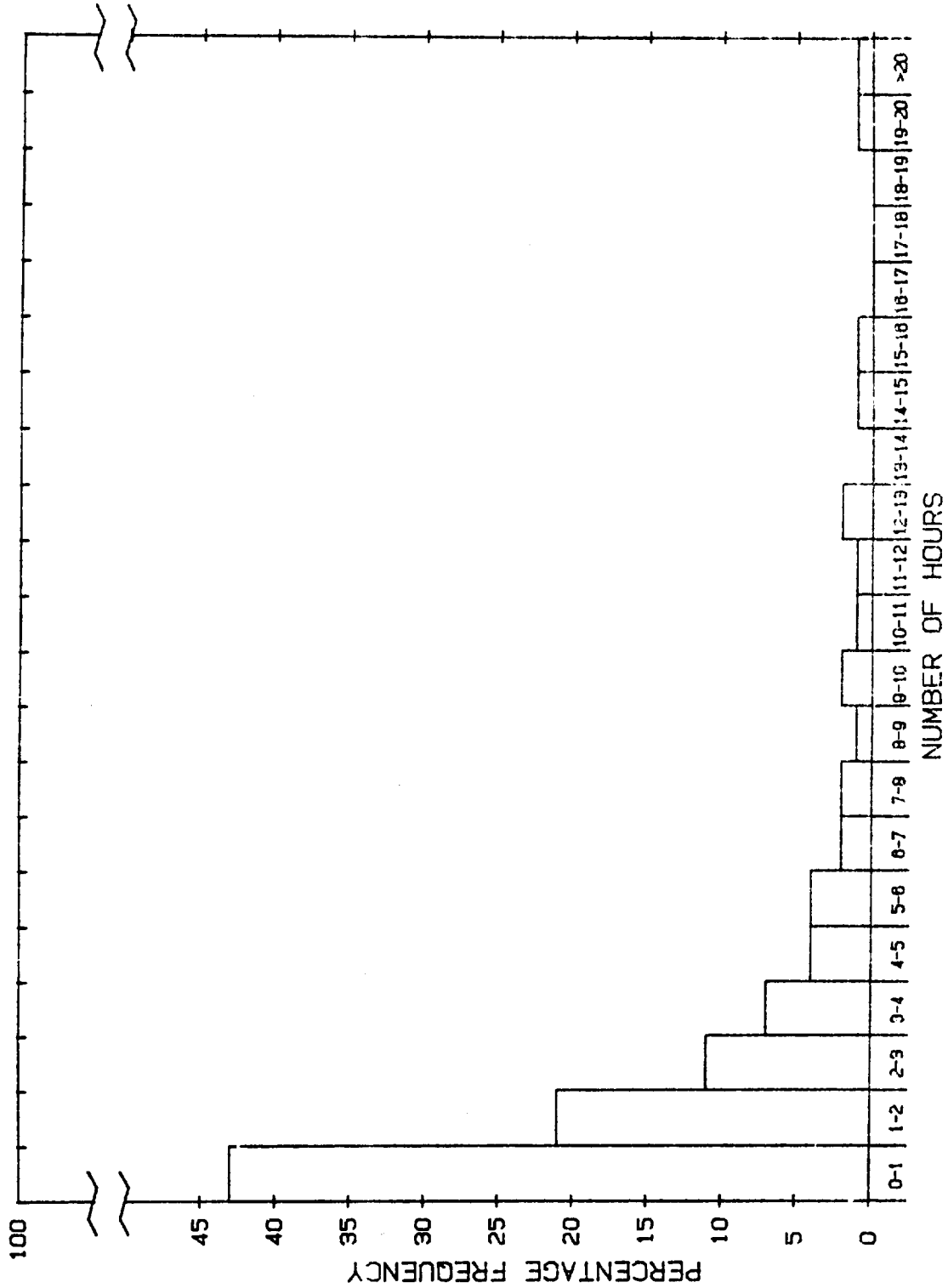


Figure A-184. Duration of Precipitation, Mean of German Airbases - August.

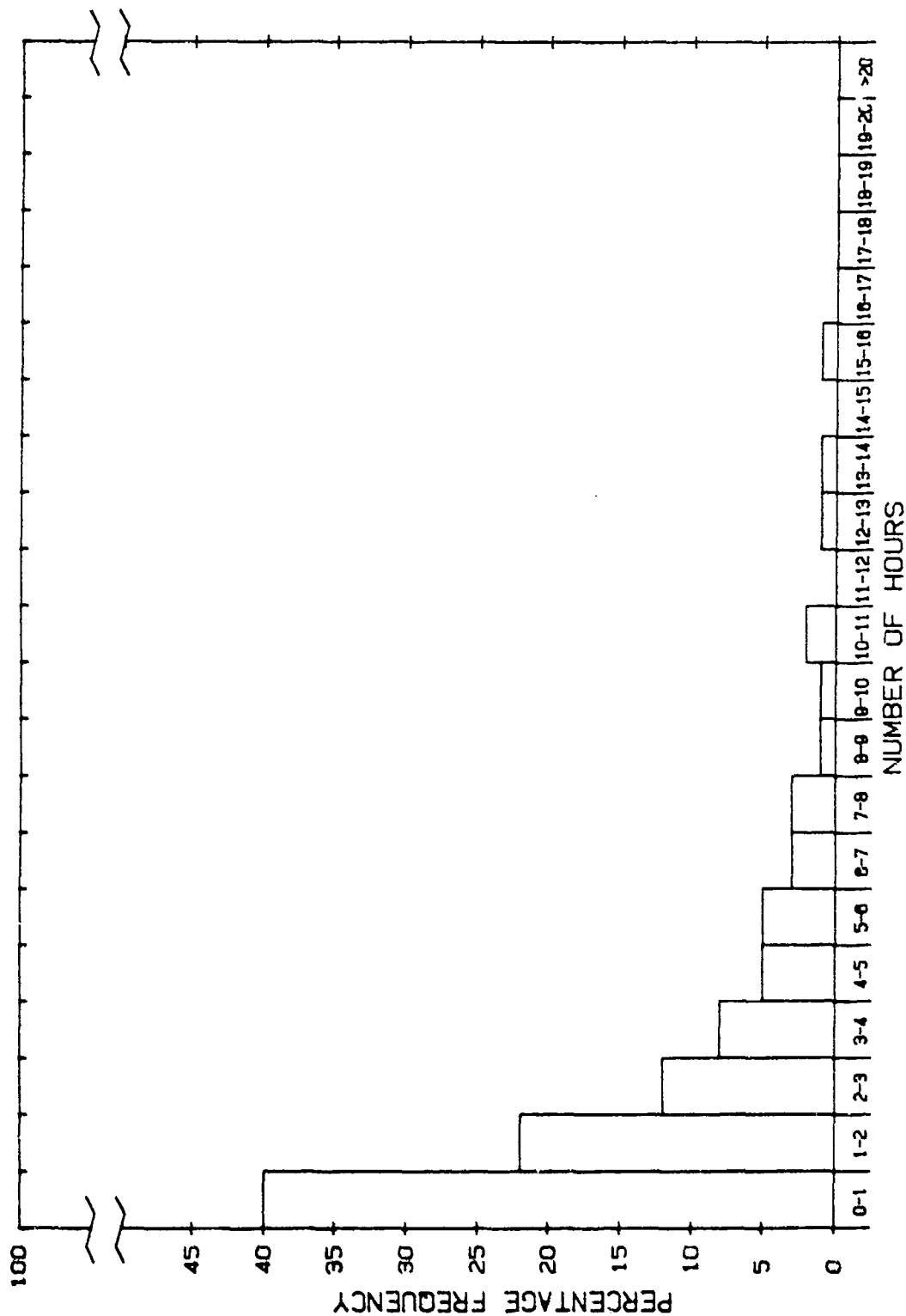


Figure A-185. Duration of Precipitation, Mean of German Airbases - September.

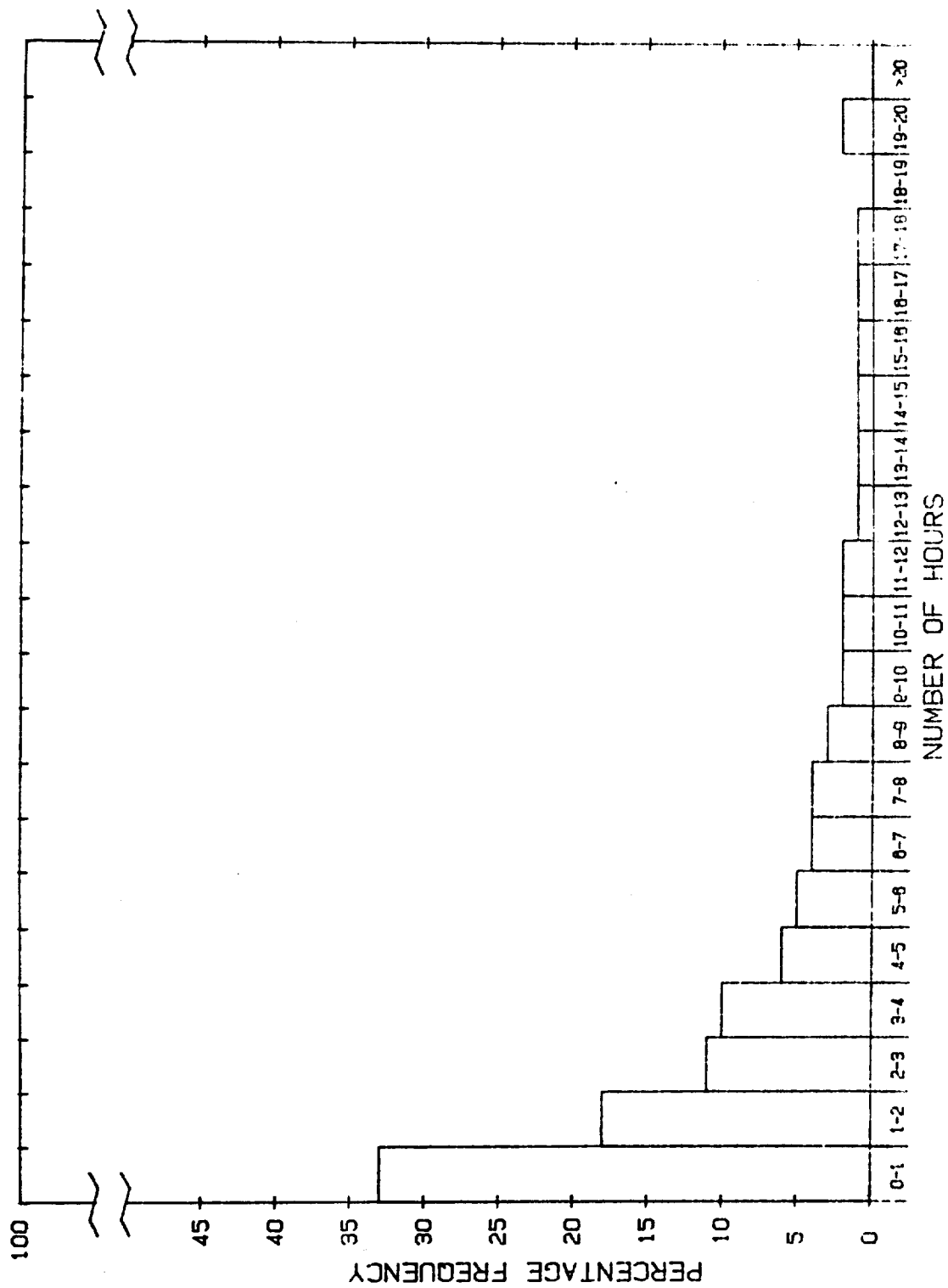


Figure A-186. Duration of Precipitation, Mean of German Airbases - October.

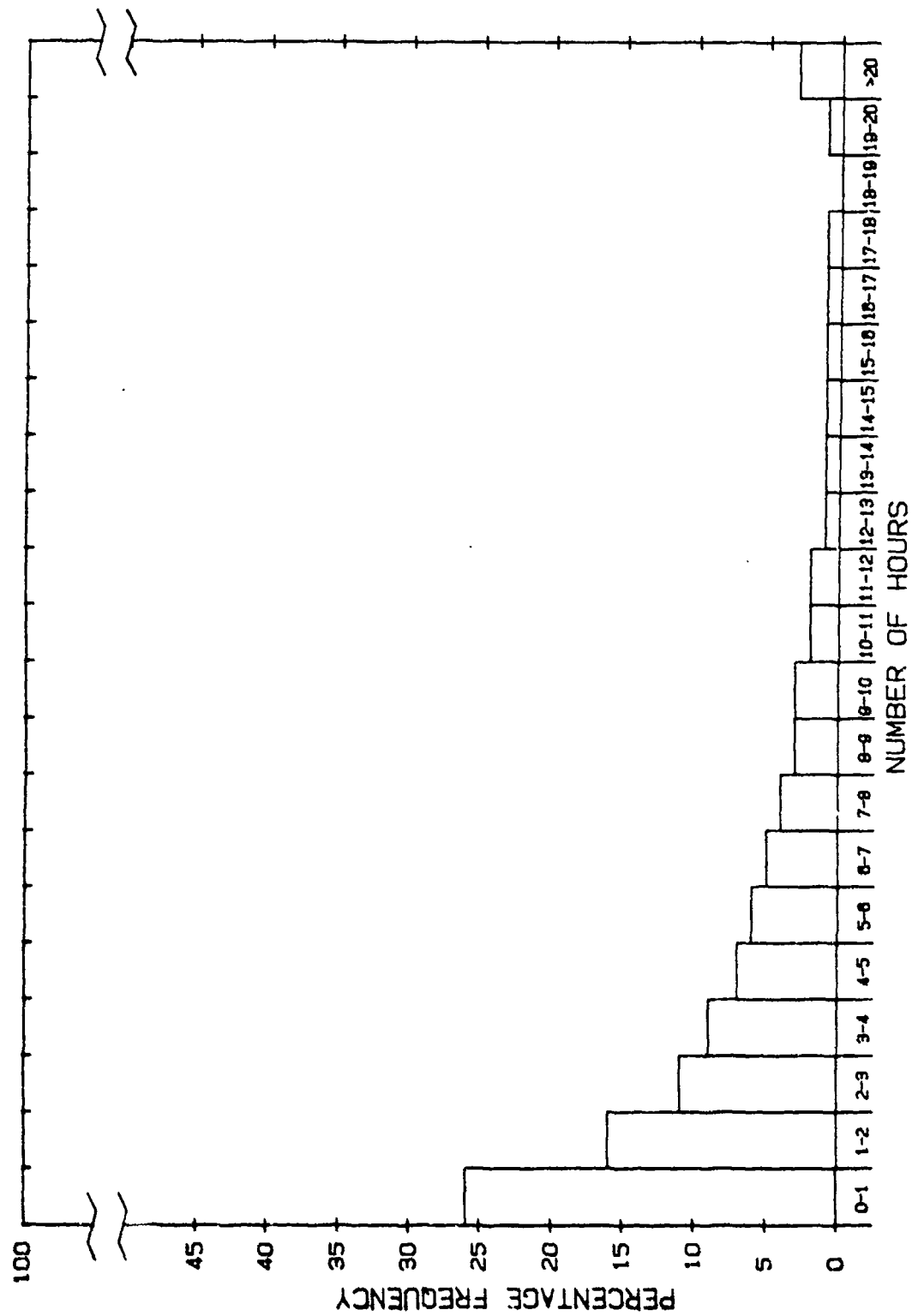


Figure A-187. Duration of Precipitation, Mean of German Airbases - November.

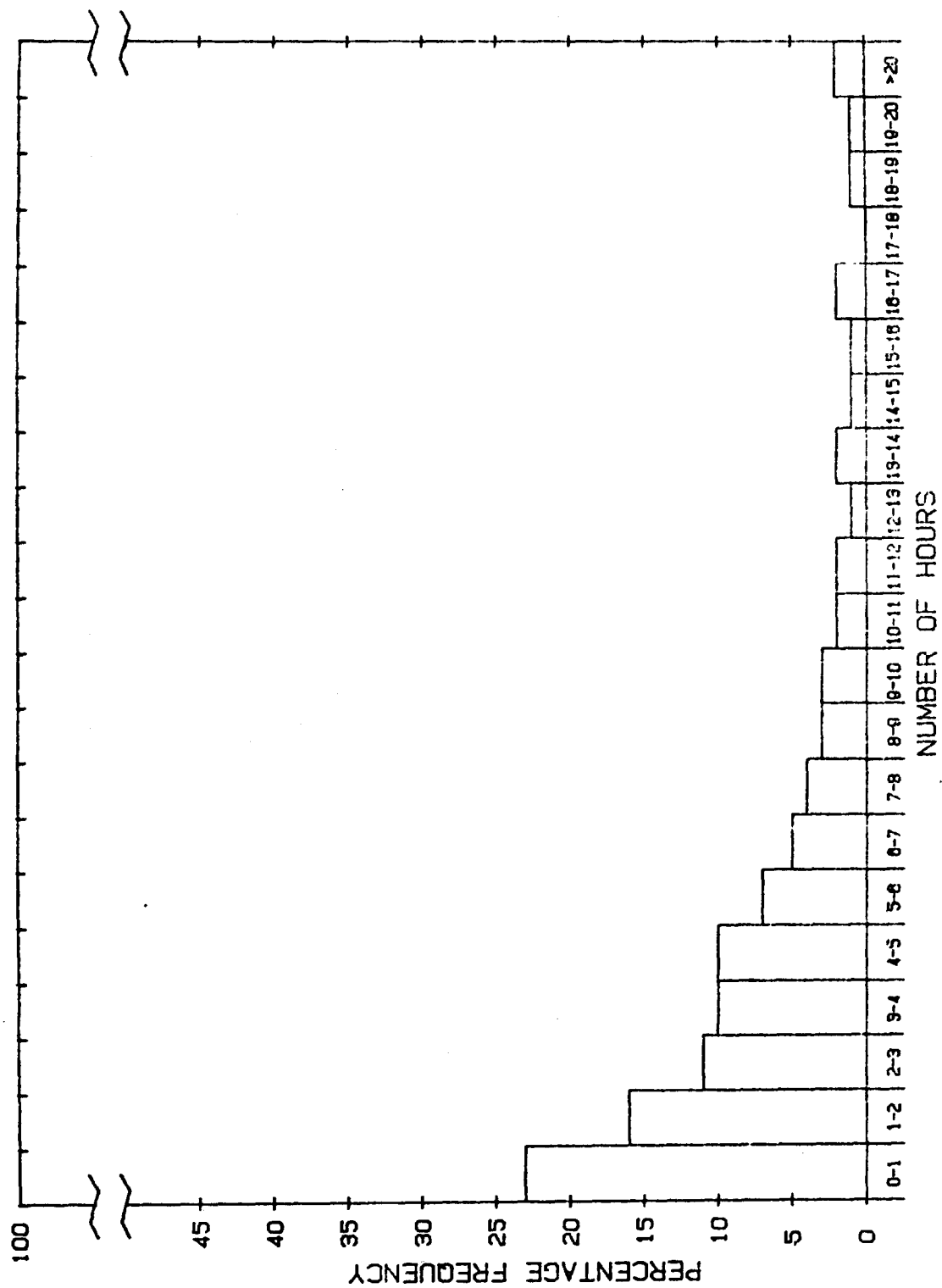


Figure A-188. Duration of Precipitation, Mean of German Airbases - December.

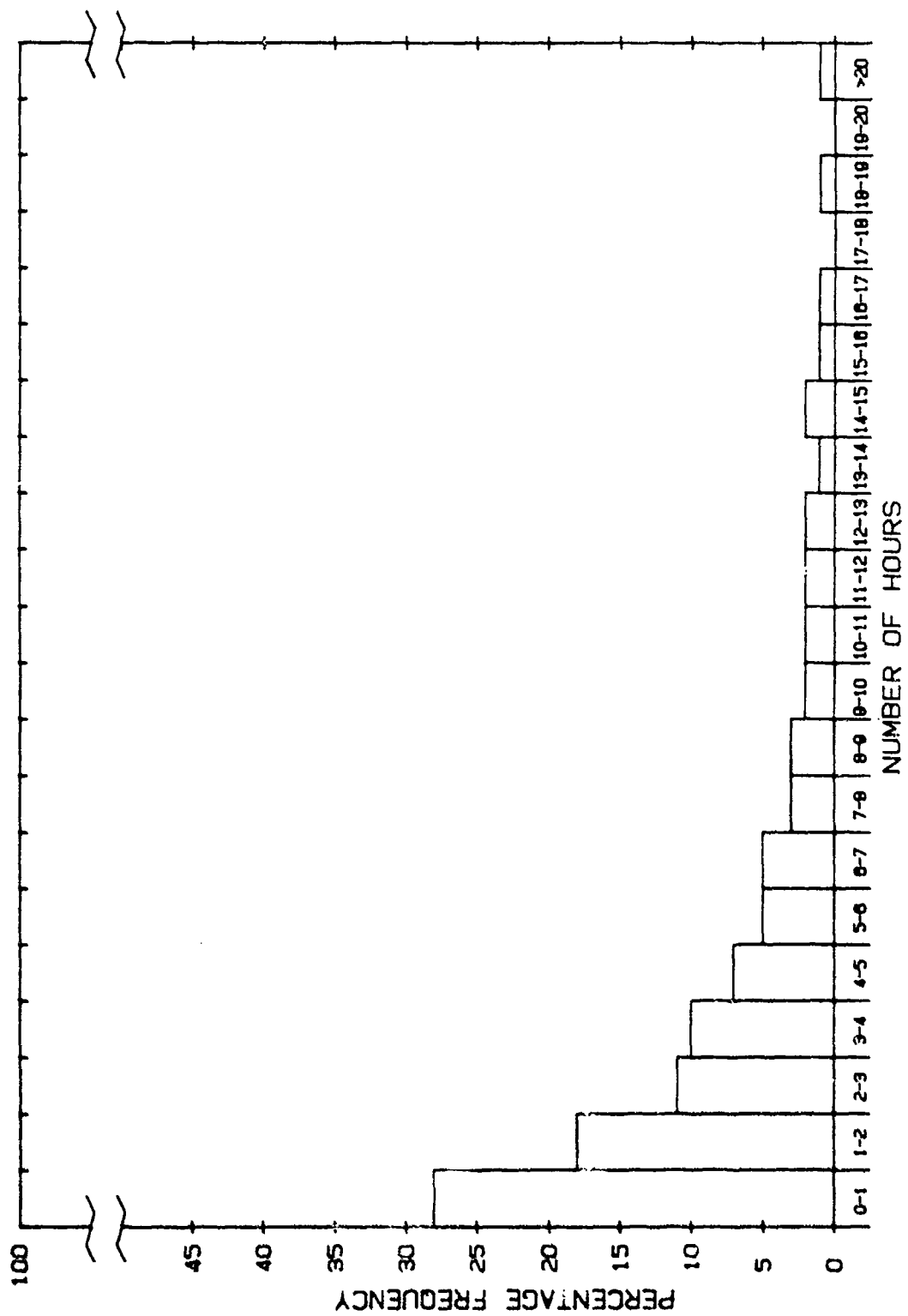


Figure A-189. Duration of Precipitation, Mean of Korean Airbases - January.

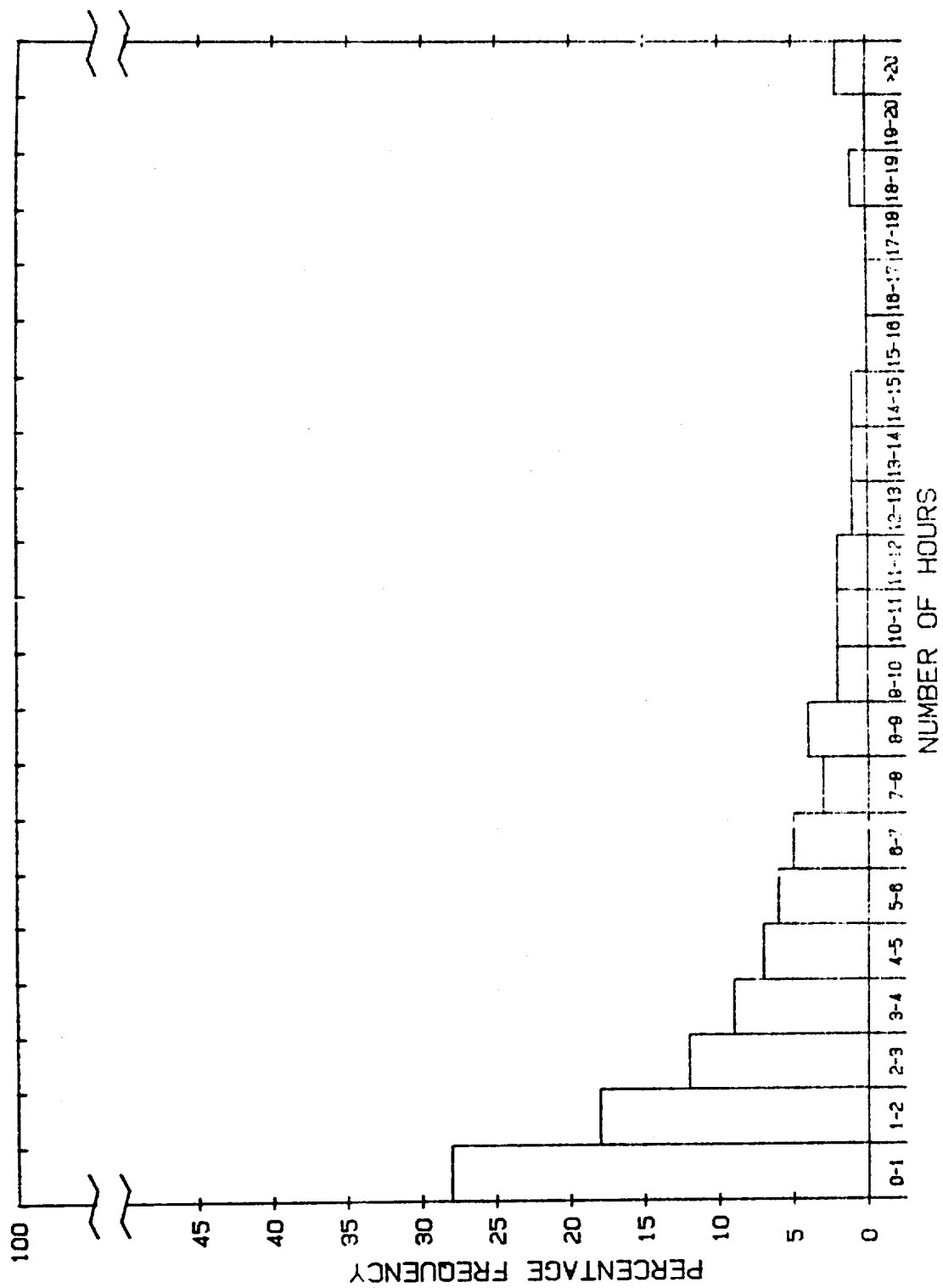


Figure A-190. Duration of Precipitation, Mean of Korean Airbases - February.

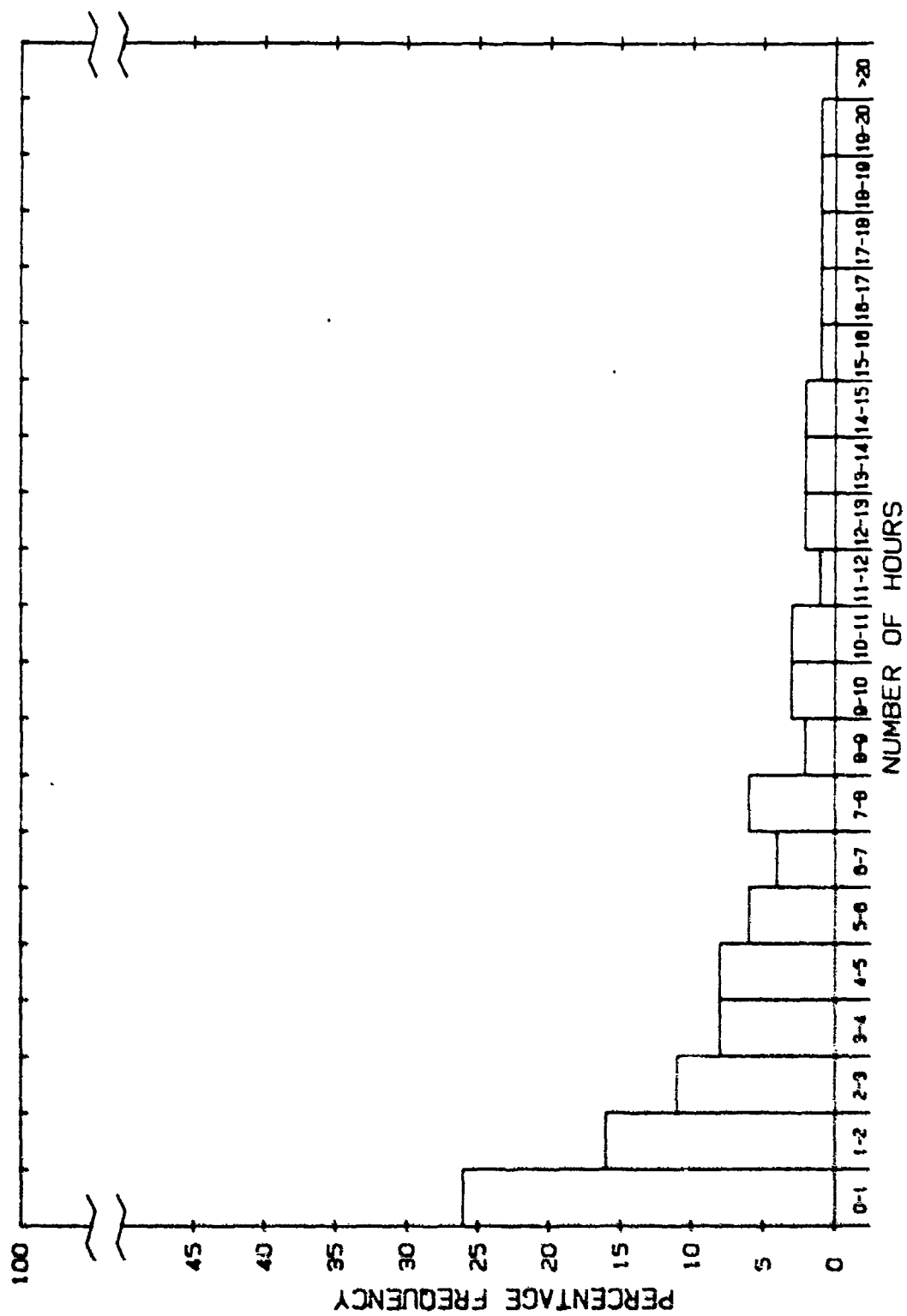


Figure A-191. Duration of Precipitation, Mean of Korean Airbases - March.

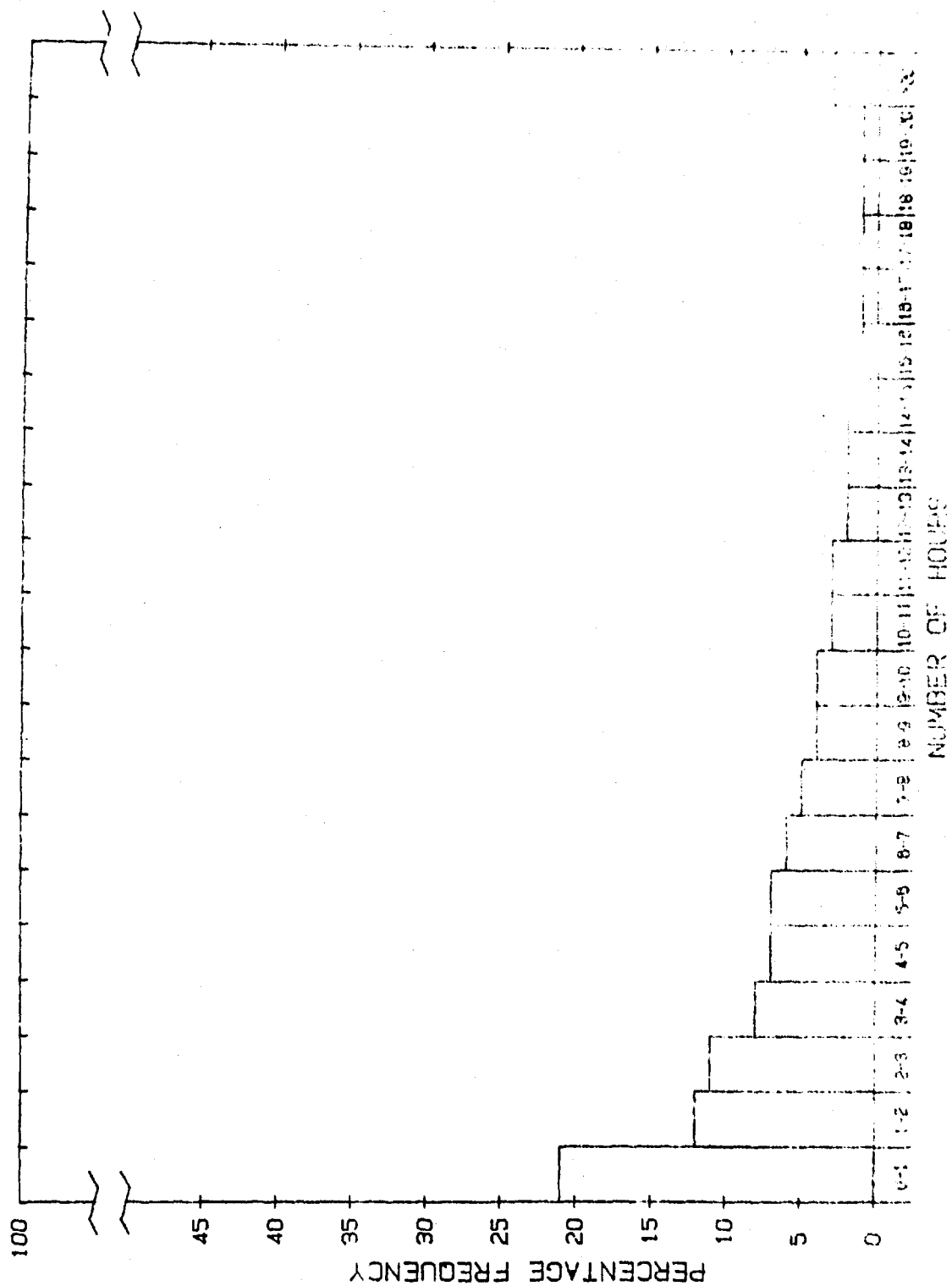


Figure A-192. Duration of precipitation, Mean of Korea Airbases - April.

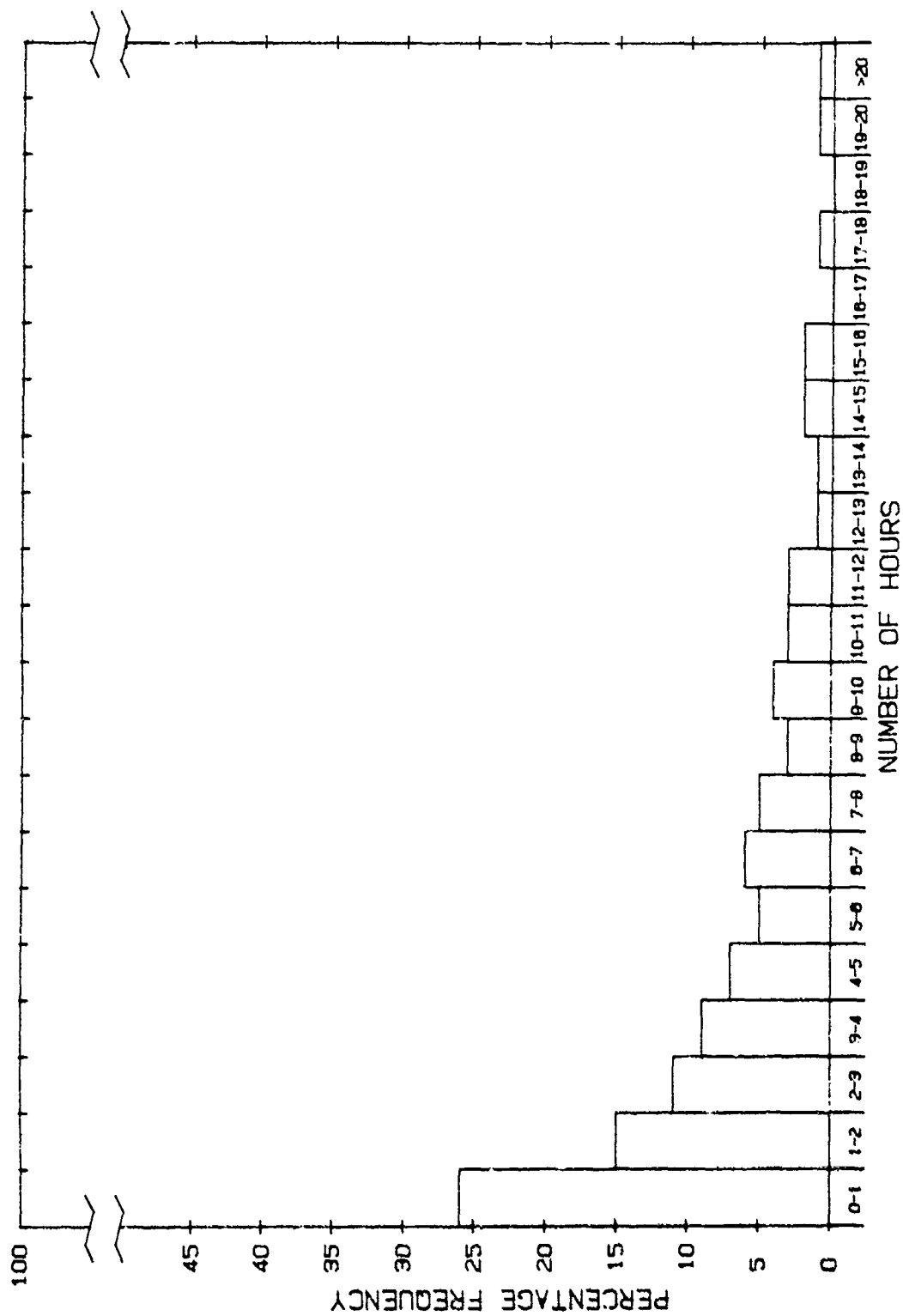


Figure A-193. Duration of Precipitation, Mean of Korean Airbases - May.

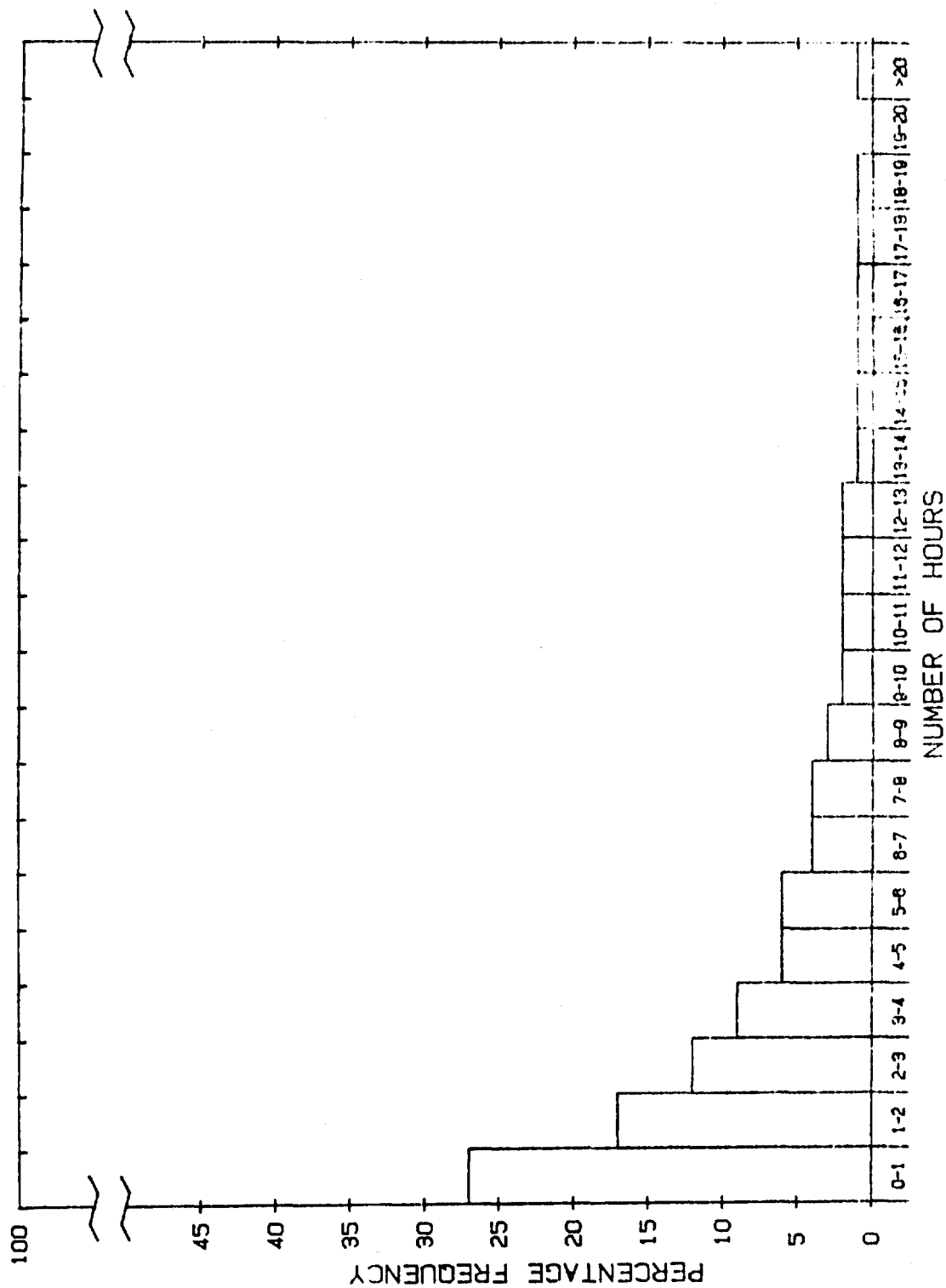


Figure A-194. Duration of Precipitation, Mean of Korean Airbases - June.

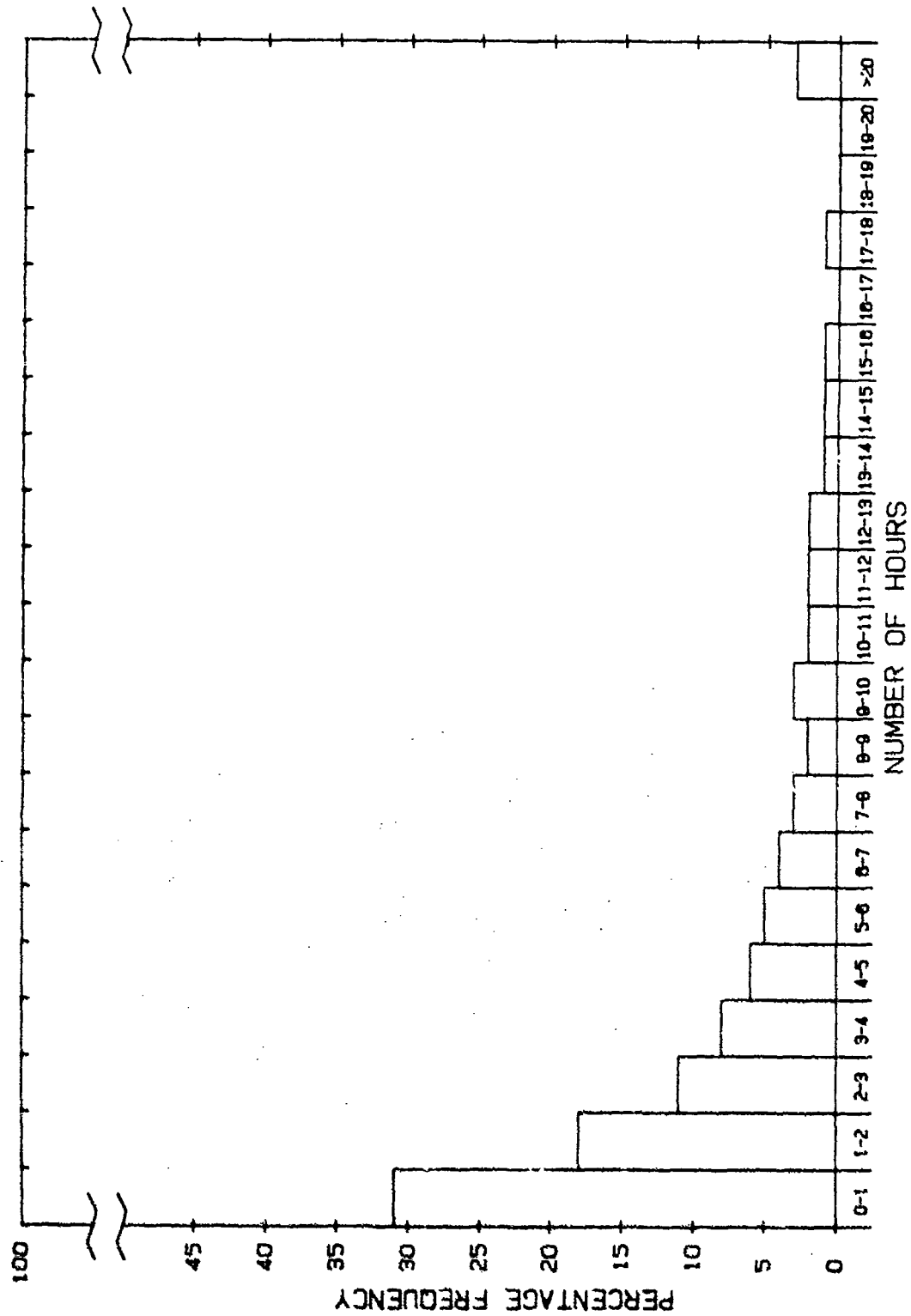


Figure A-195. Duration of Precipitation, Mean of Korean Airbases - July.

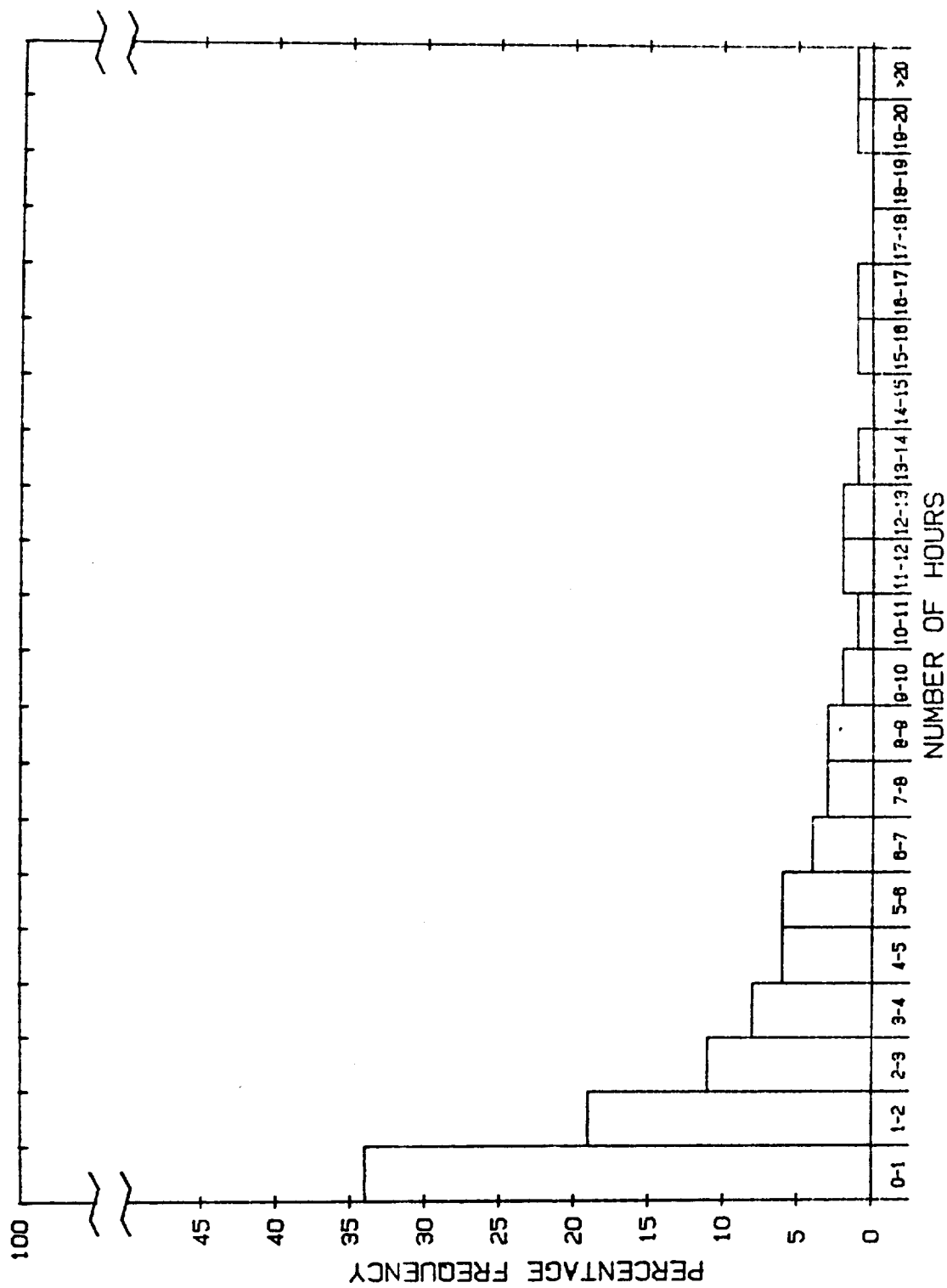


Figure A-196. Duration of Precipitation, Mean of Korean Airbases - August.

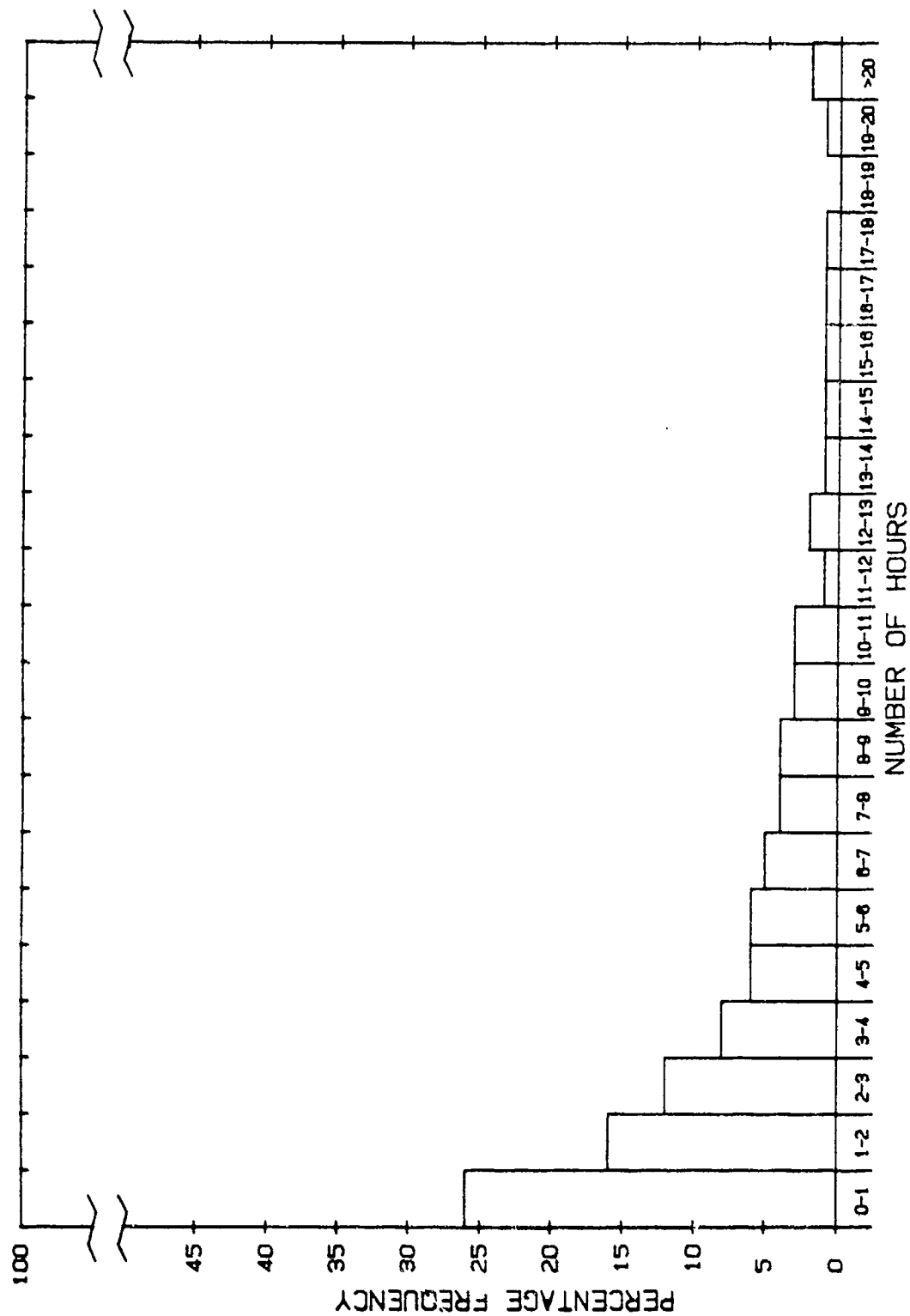


Figure A-197. Duration of Precipitation, Mean of Korean Airbases - September.

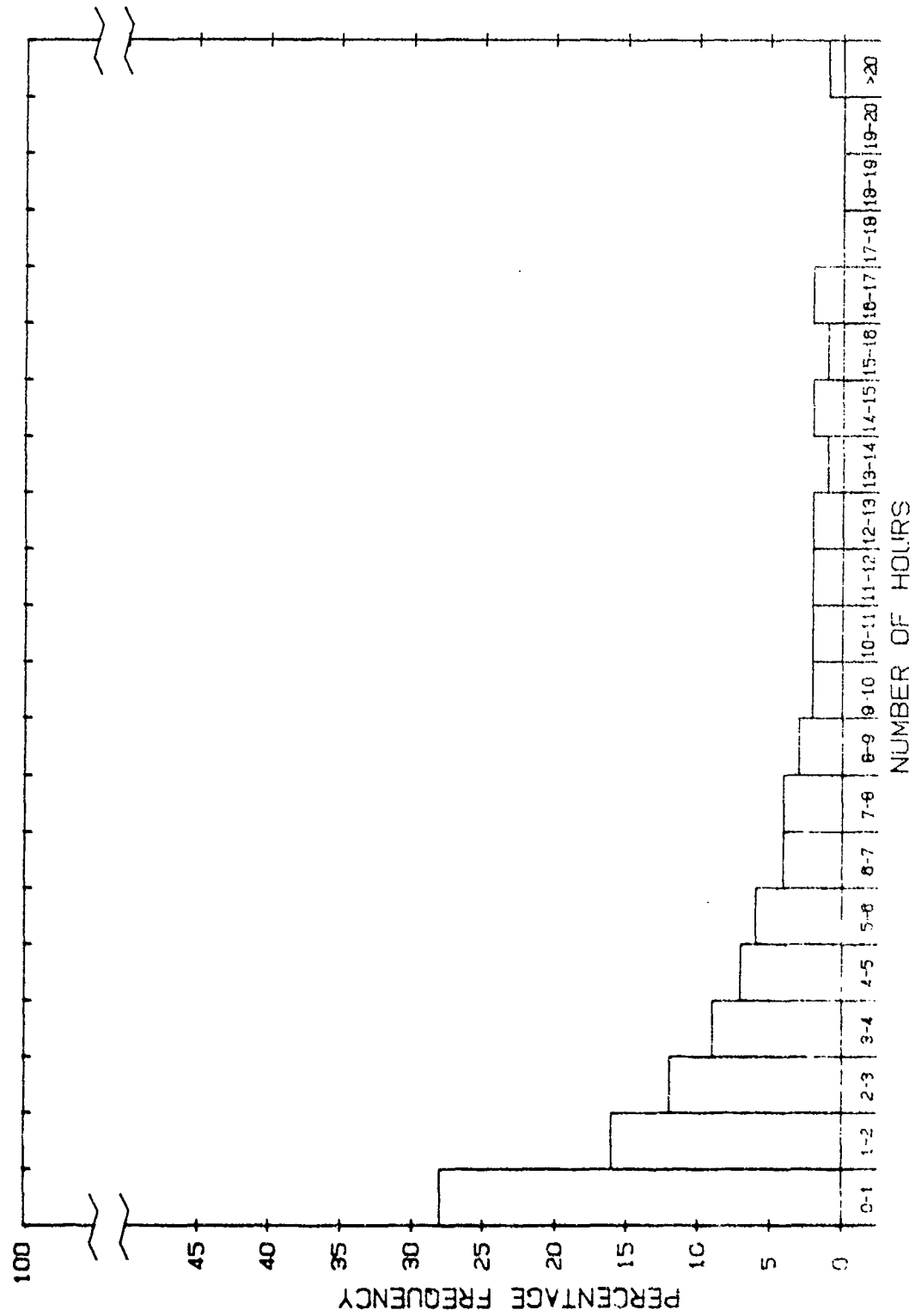


Figure A-198. Duration of Precipitation, Mean of Korean Airbases - October.

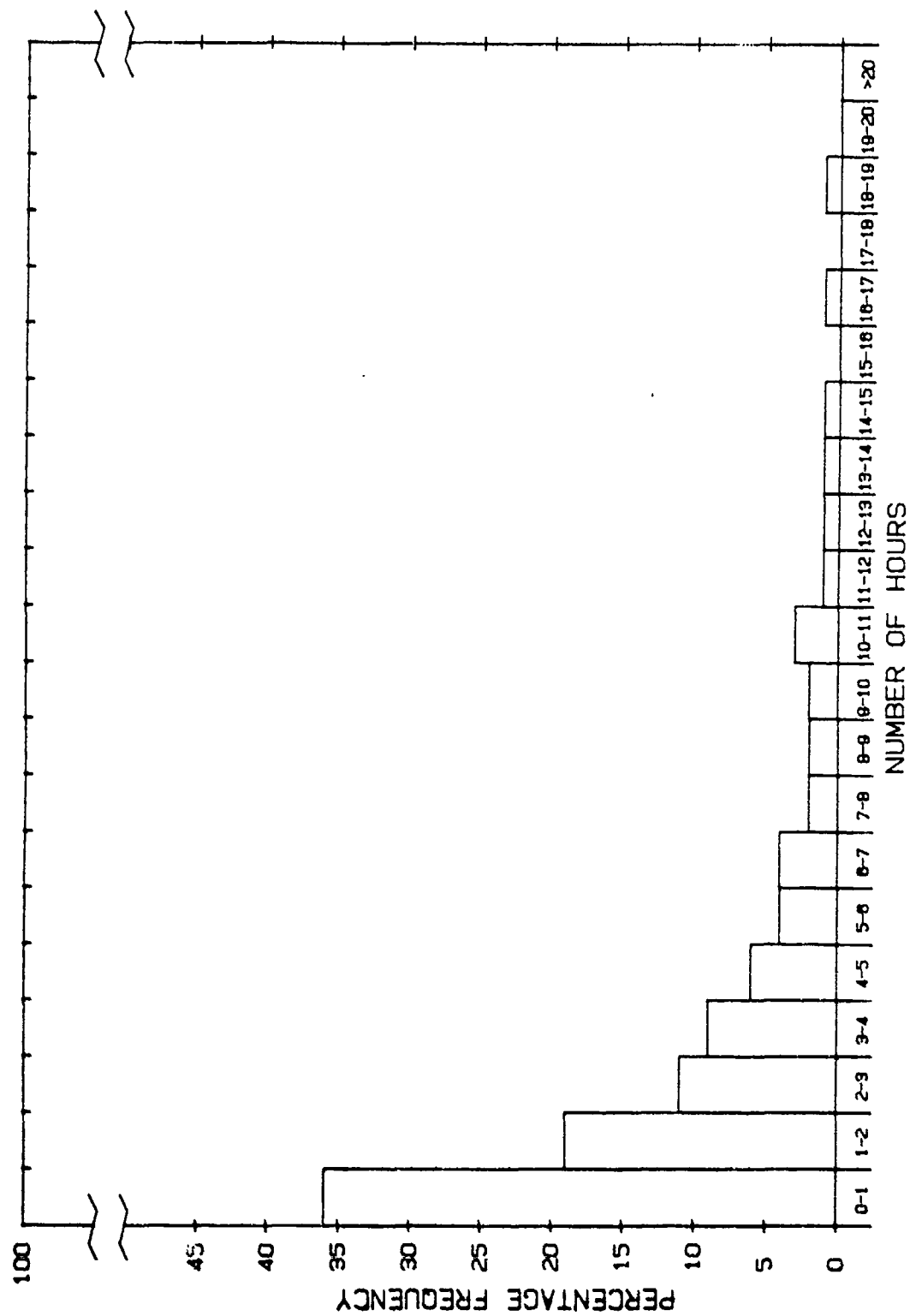


Figure A-199. Duration of Precipitation, Mean of Korean Airbases - November.

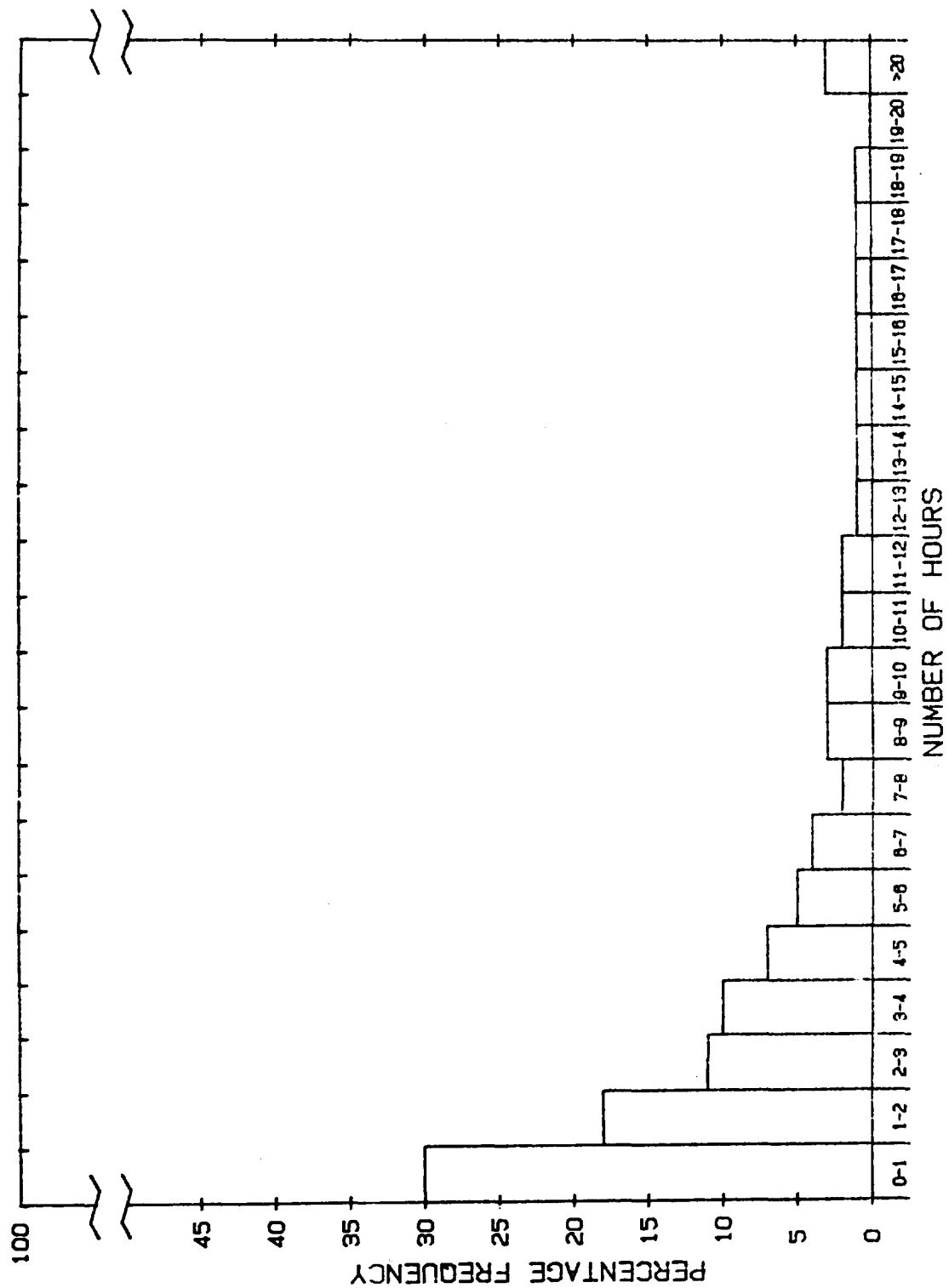


Figure A-200. Duration of Precipitation, Mean of Korean Airbases - December.

3. VISIBILITY

Horizontal, or ground visibility is defined as the greatest distance, during the day, from which a dark object can be recognized against the horizon sky; at night it is the greatest distance from which a moderately intense light can be seen.

a. Frequency of Occurrence of Indicated Visibilities:

$V \leq 1/4, 5/16, 1/2$ Mile

For each airbase in a theater, visibility was recorded at hourly intervals. These statistics were computed by determining the percentage of those observations that were within each visibility range for the month. The highest frequency of occurrence of low visibility ranges was assumed to be the worst case. Only worst-case data are included for Germany and Korea since mean values were very low.

EXAMPLE: Consider Upper Heyford in January (Figure A-201). During this month, 6 percent of the observations recorded visibility $\leq 1/2$ mile; 4 percent recorded visibility $\leq 5/16$ mile; and 3 percent had a visibility of $\leq 1/4$ mile.



Figure A-201. Frequency of Occurrence of Indicated Visibilities, Upper Heyford.

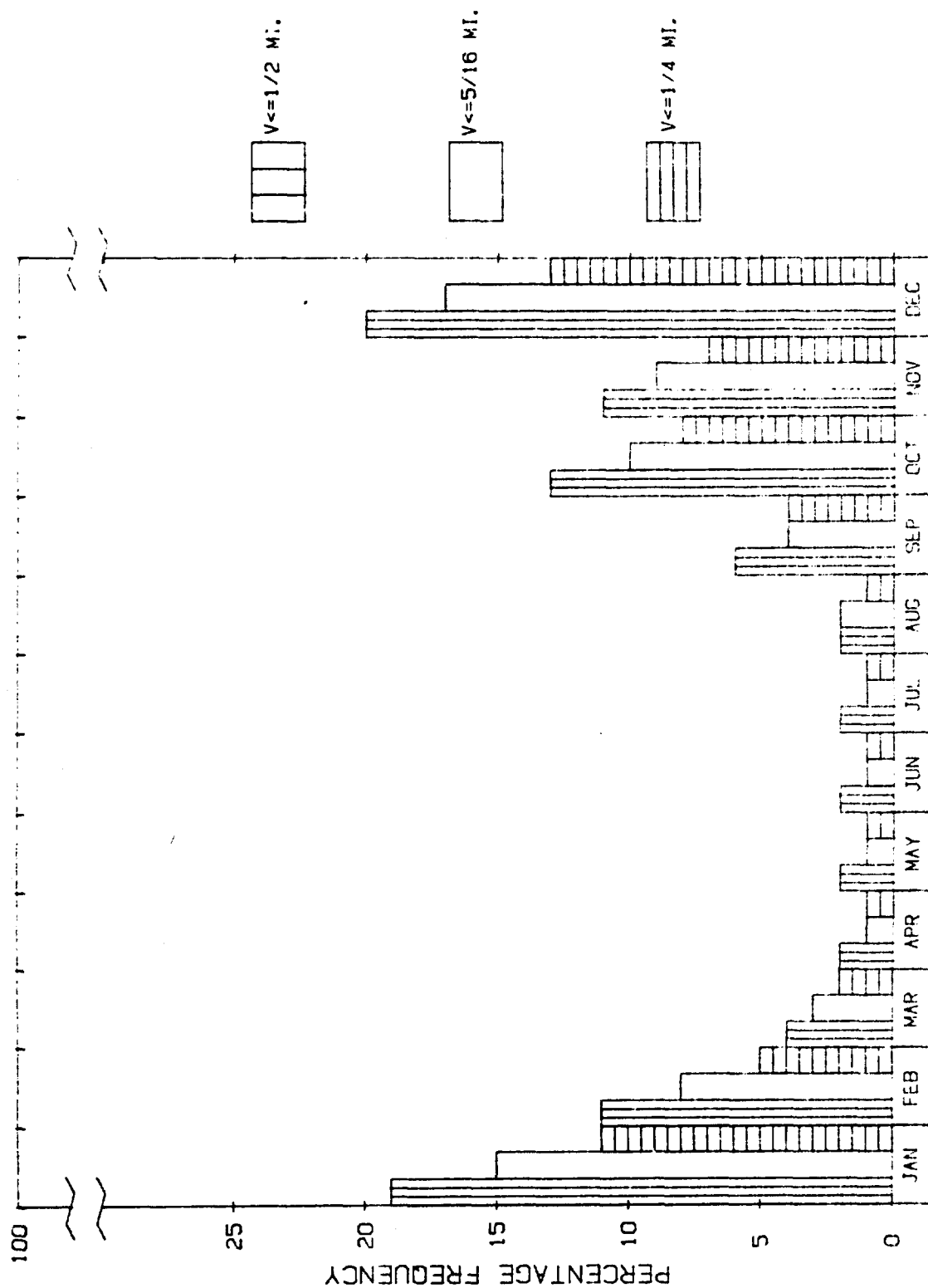


Figure A-202. Frequency of Occurrence of Indicated Visibilities, Worst Case: Germany.

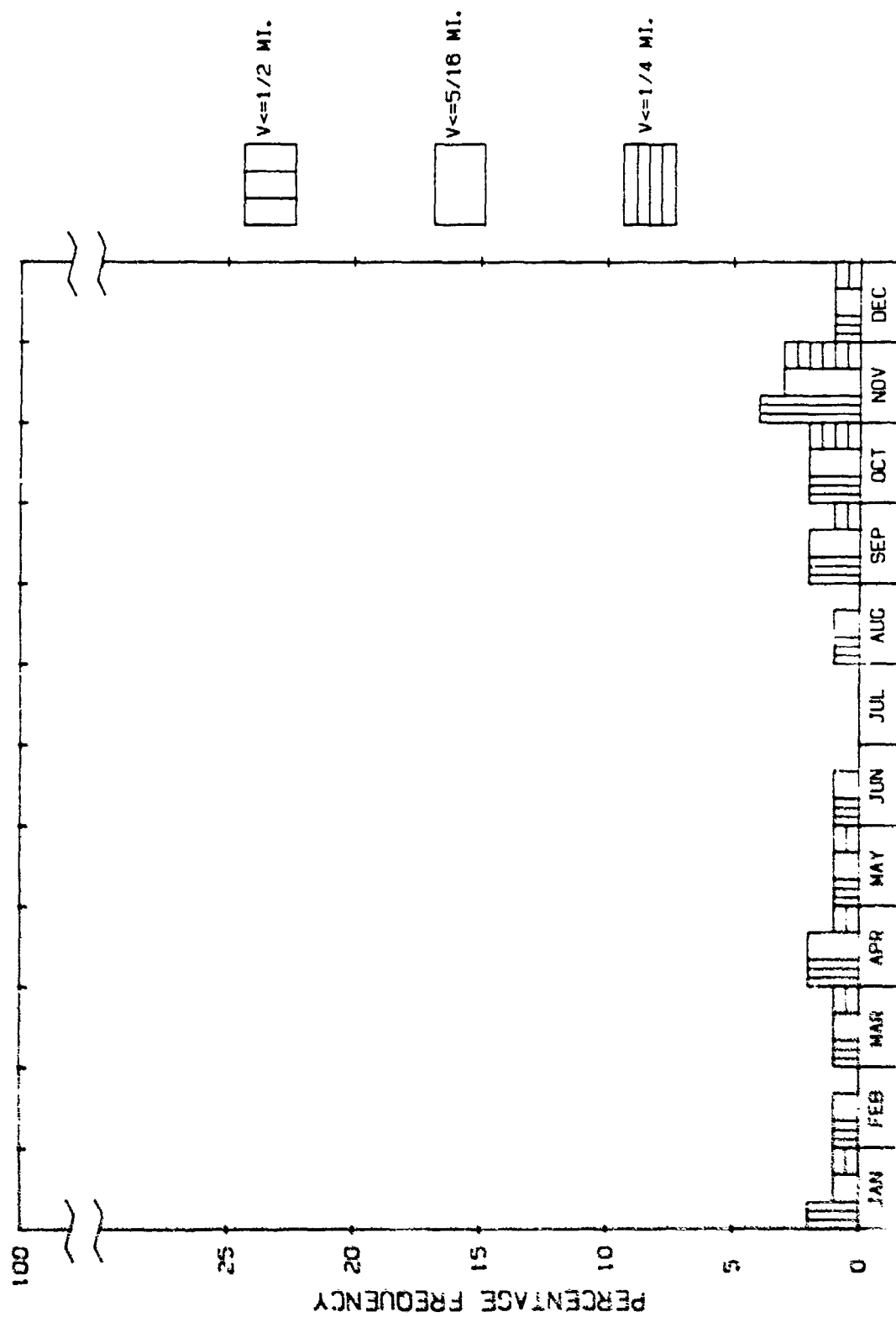


Figure A-203. Frequency of Occurrence of Indicated Visibilities, Worst Case: Korea.

b. Duration of Visibility \leq 990 Feet

These graphs represent unconditional duration of visibility for at least the number of hours indicated. The conditional probability of the duration could be calculated by considering the ratio of unconditional duration of visibility \leq 990 feet to the percent of total observations of visibility \leq 990 feet.

The worst case worldwide was considered to show that low visibility is generally not a problem in any of the three theaters.

EXAMPLE: Consider Figure A-204. In January, only 5 percent of the total number of observations recorded the visibility to be \leq 990 feet. Approximately 1 percent of the observations were from periods where the visibility was \leq 990 feet for at least 5 hours. Thus, the conditional duration is $1/5 = 0.20$. That is, given that the visibility was recorded to be \leq 990 feet, 20 percent of the time the visibility remained at that level for at least 5 hours.

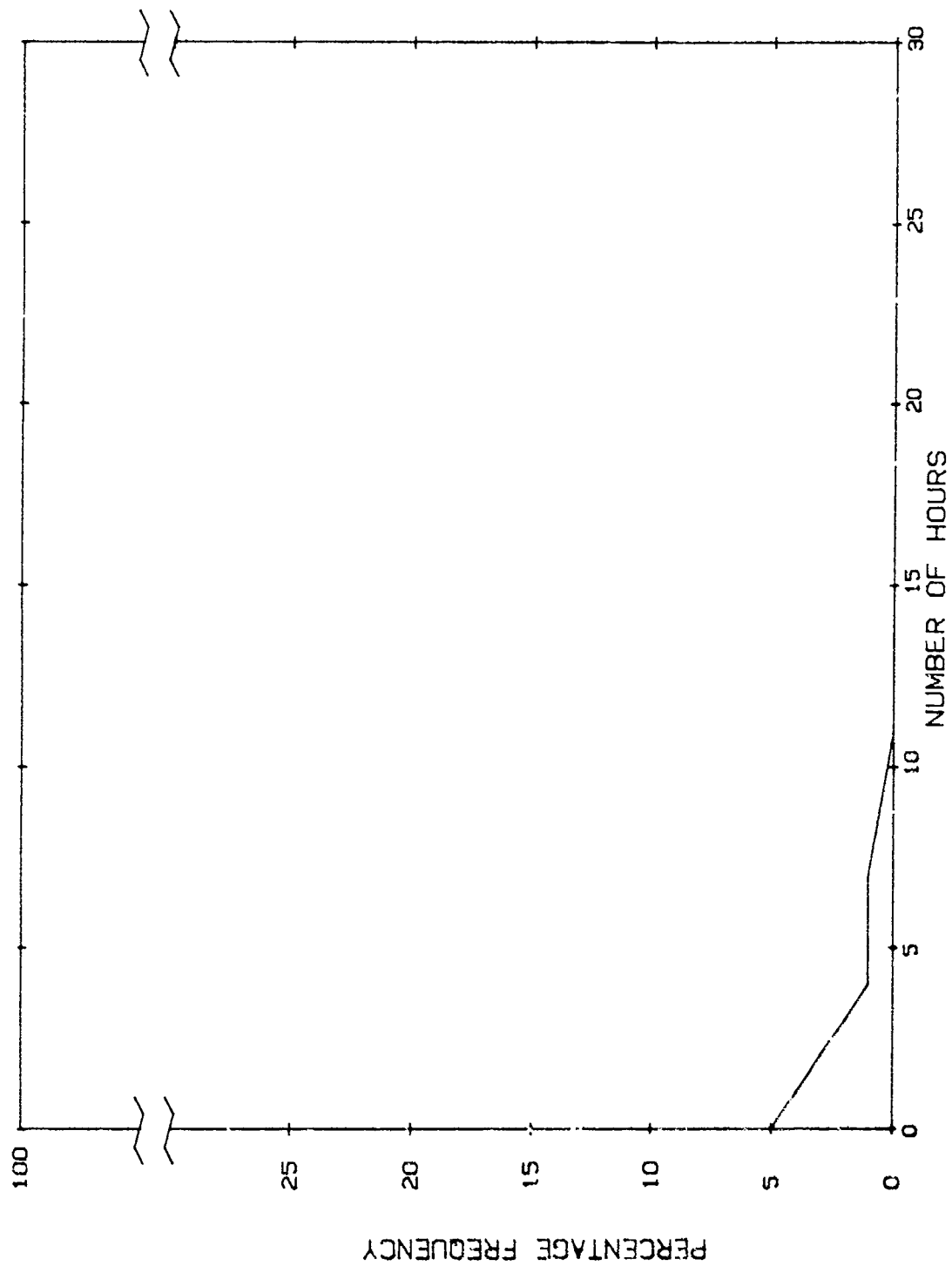


Figure A-204. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - January.

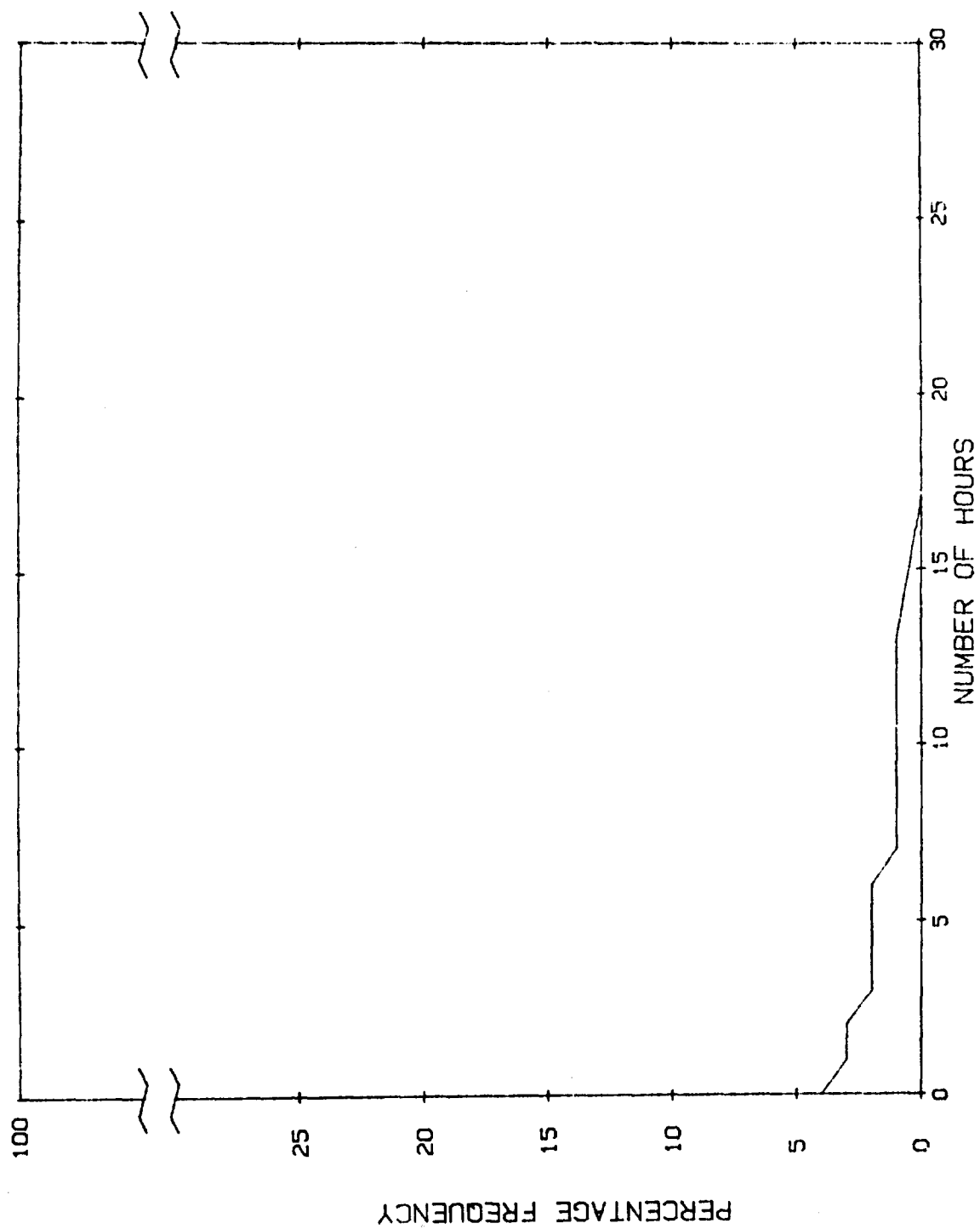


Figure A-205. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - February.

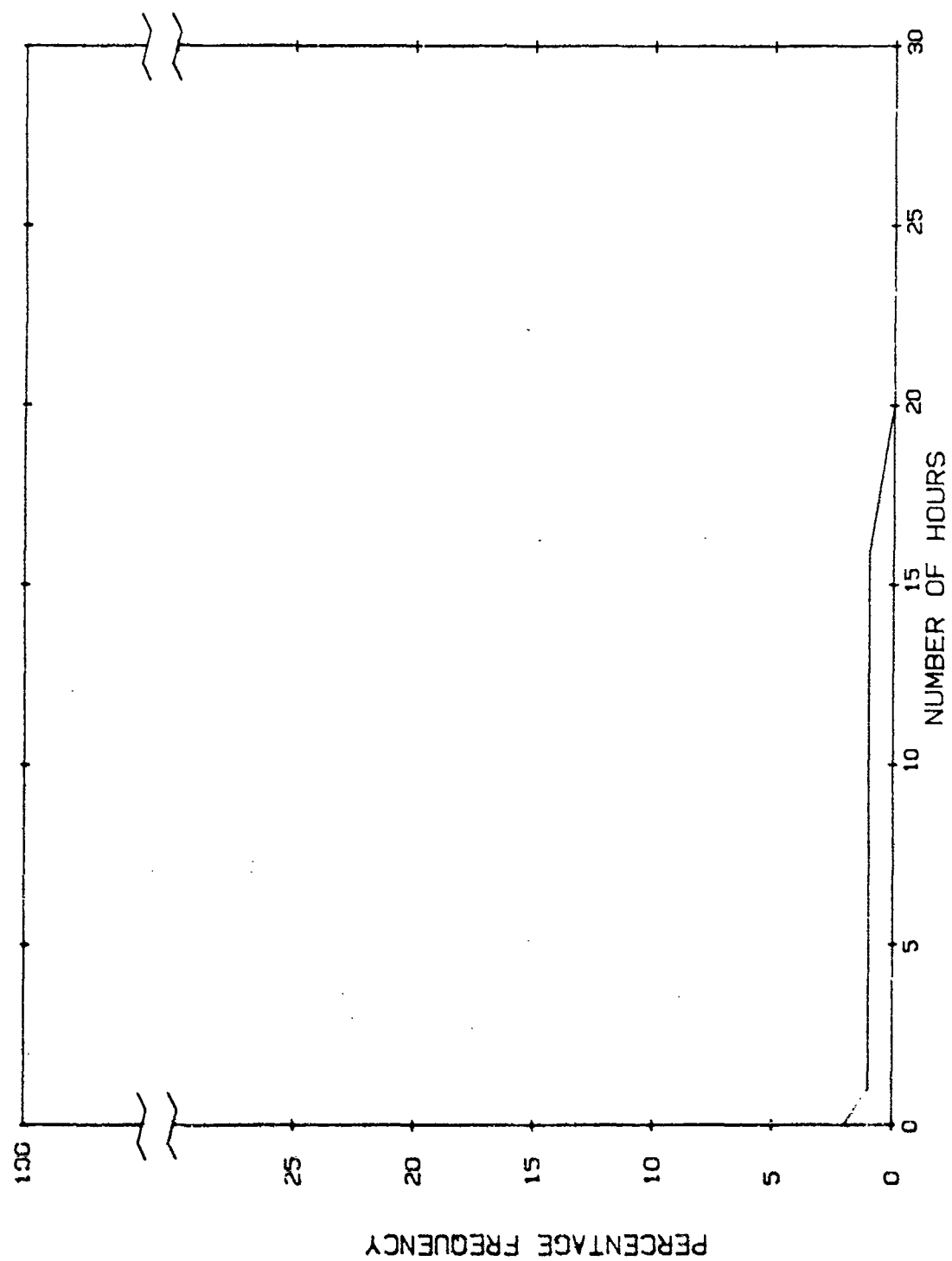


Figure A-206. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - April.

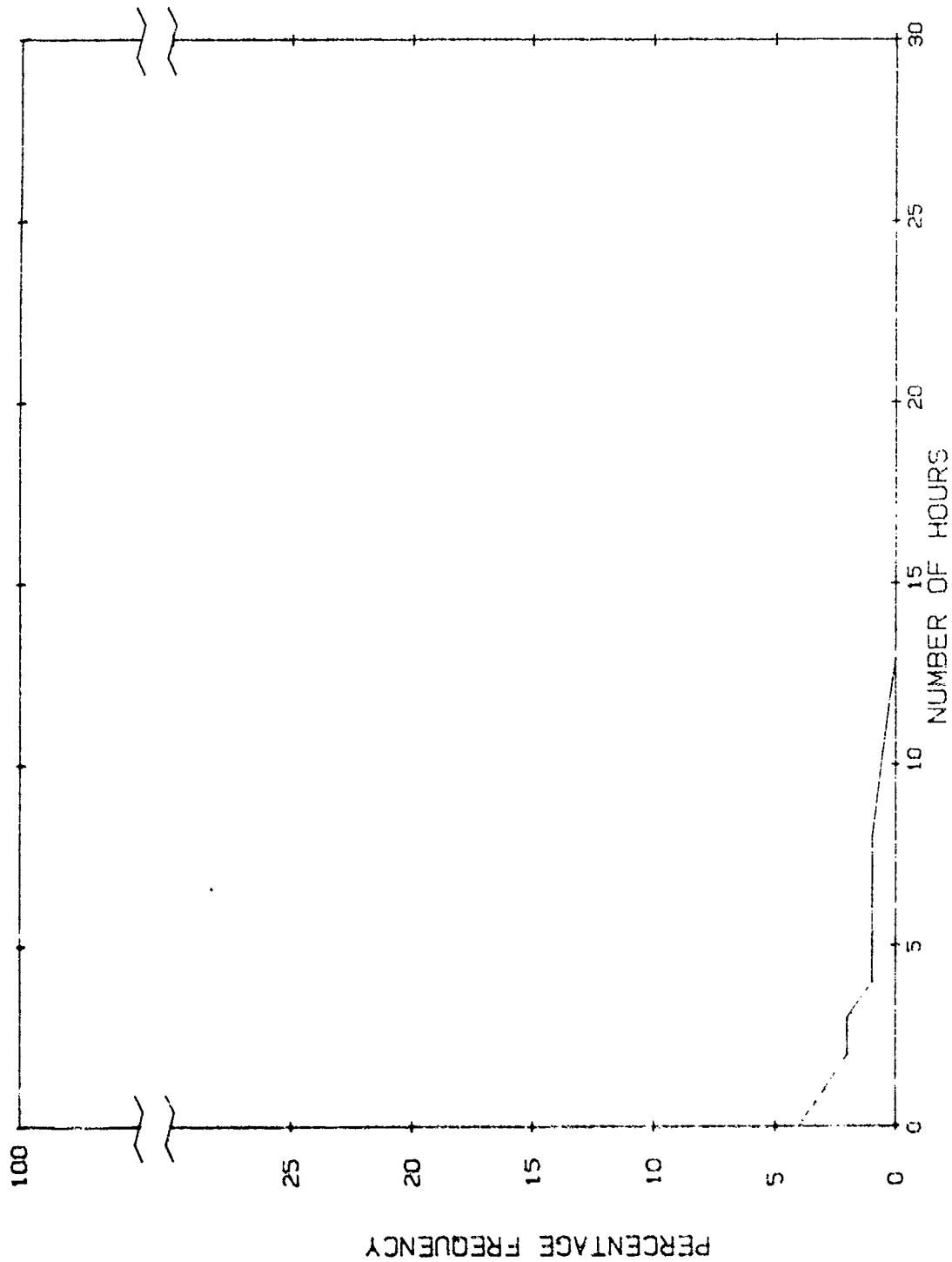


Figure A-207. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - September.

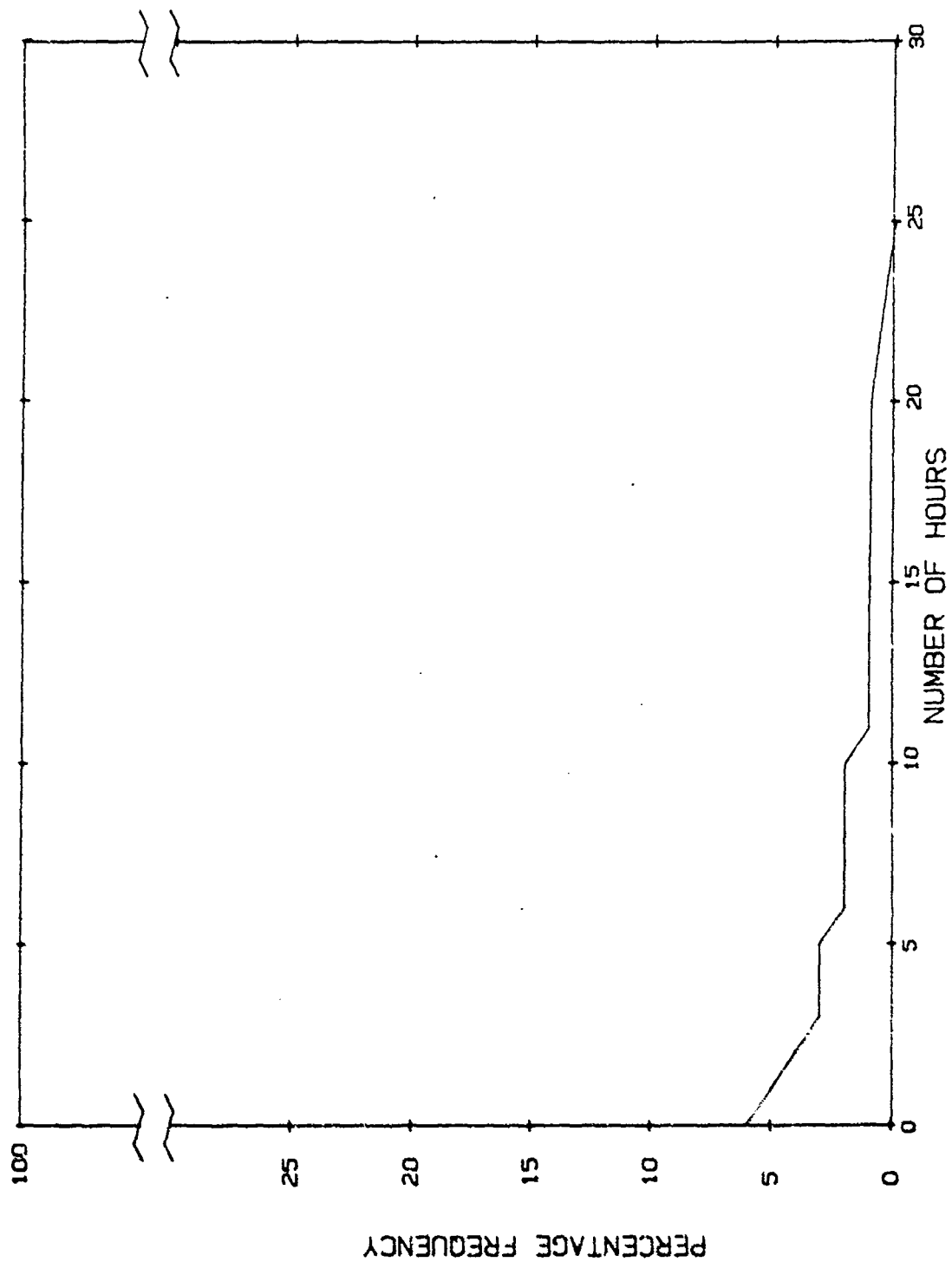


Figure A-208. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - October.

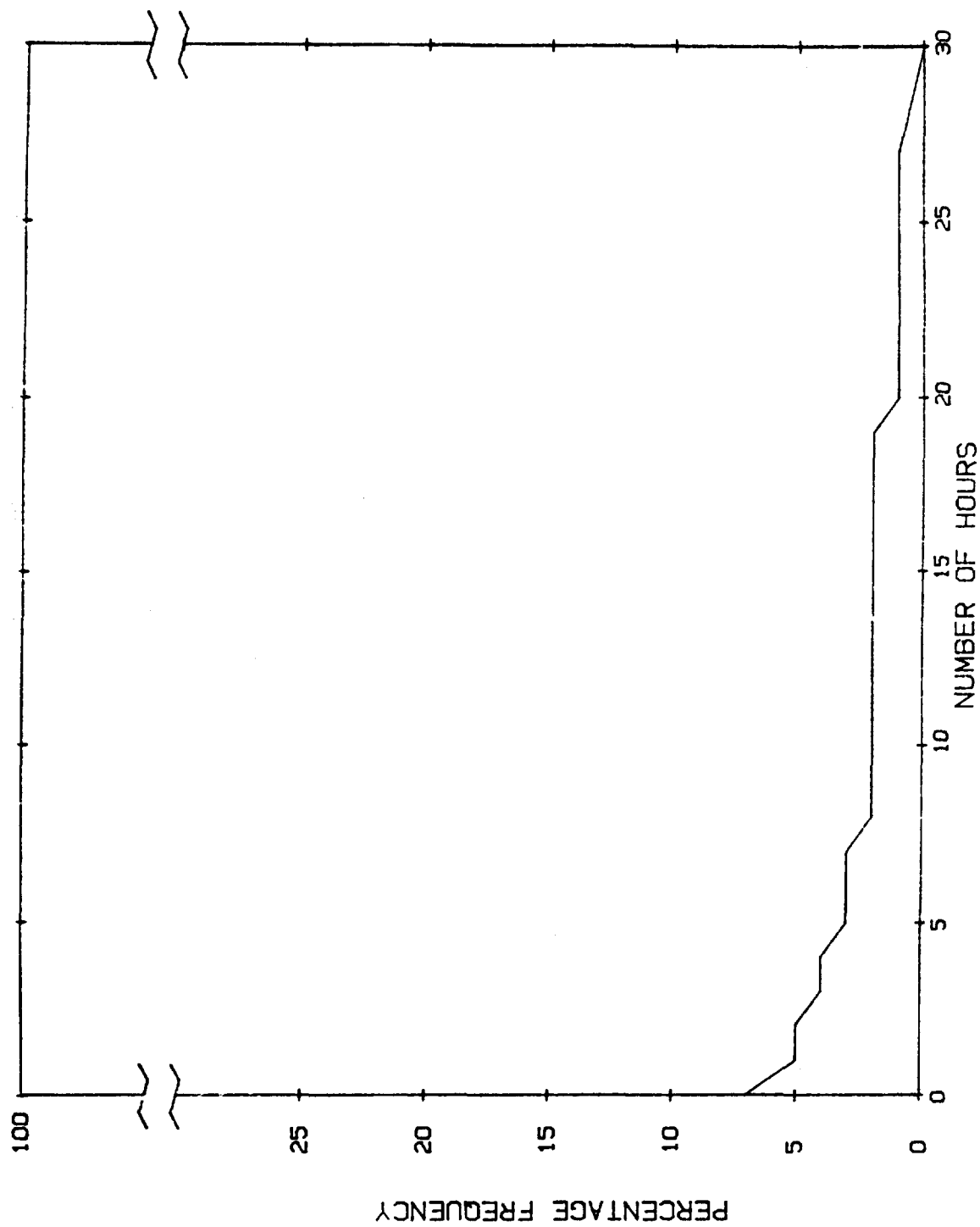


Figure A-209. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - November.

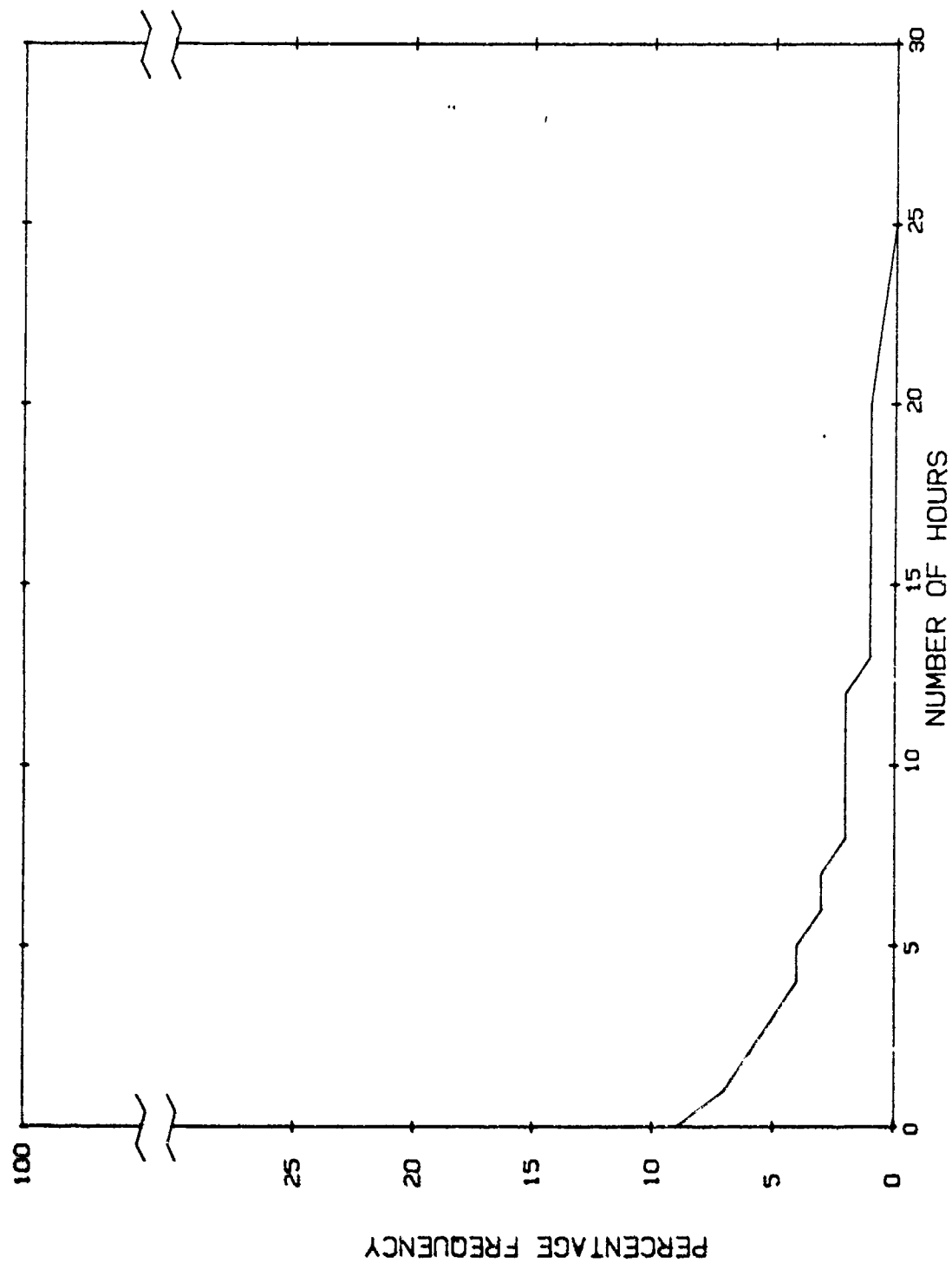


Figure A-210. Duration of Visibility \leq 990 Feet, Worst Case: Worldwide - December.

c. Frequency of Occurrence of Indicated Visibilities:

V < 400, 300, 200, 100 Meters

Visibilities were recorded hourly for each airbase in a theater and then grouped by month according to the ranges indicated on the graphs. The statistics represented in this set of graphs were determined by calculating the percentage of the total recorded values that fall within each visibility range.

These worst case worldwide data are given to show the most severe conditions in all three theaters.

EXAMPLE: Consider the frequency of occurrence of visibility < 400 meters (Figure A-211). In the worst case over all the airbases, this occurred in 8 percent of the hourly observations in February.

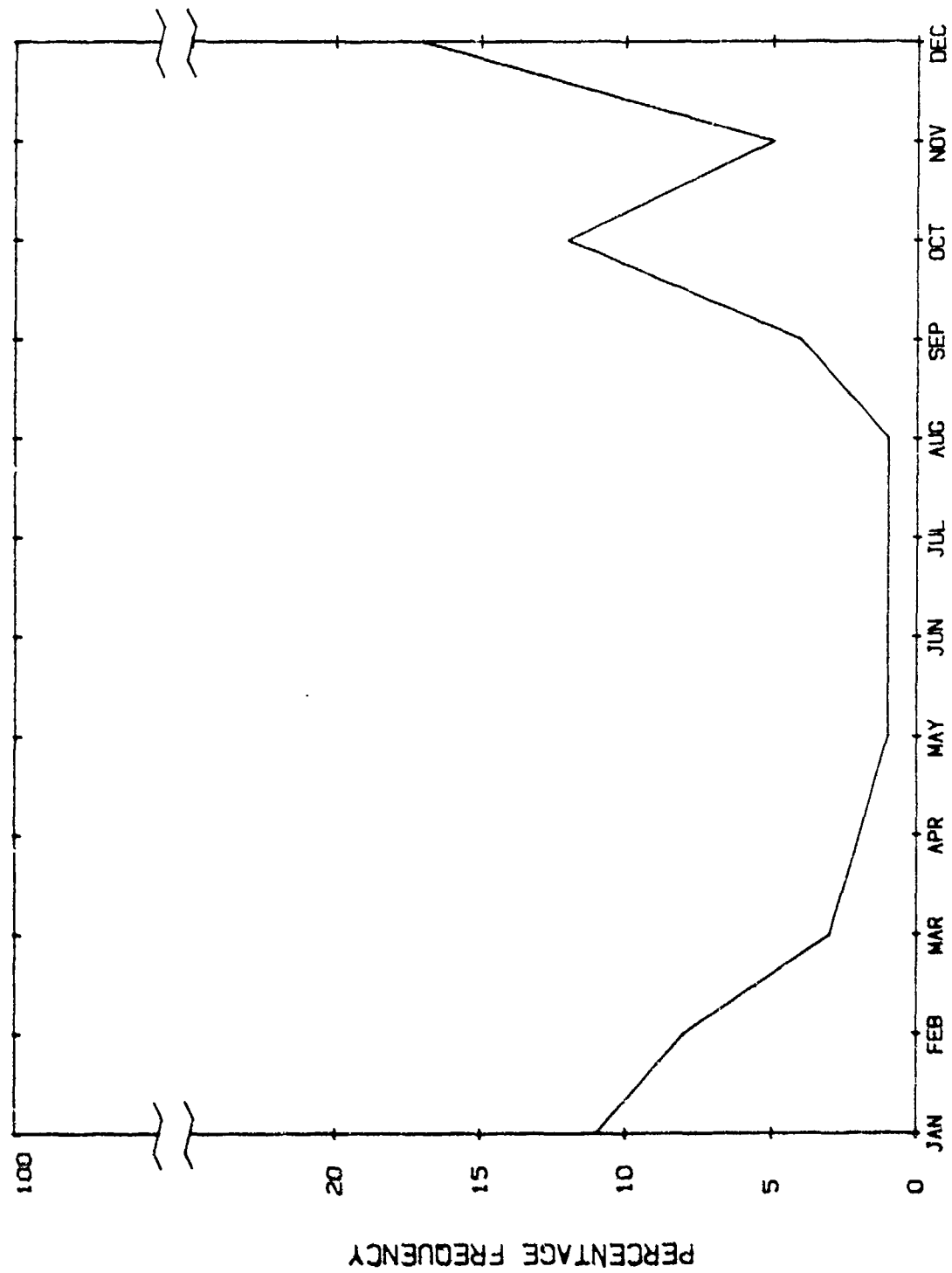


Figure A-211. Frequency of Occurrence Visibility < 400 Meters, Worst Case: Worldwide.

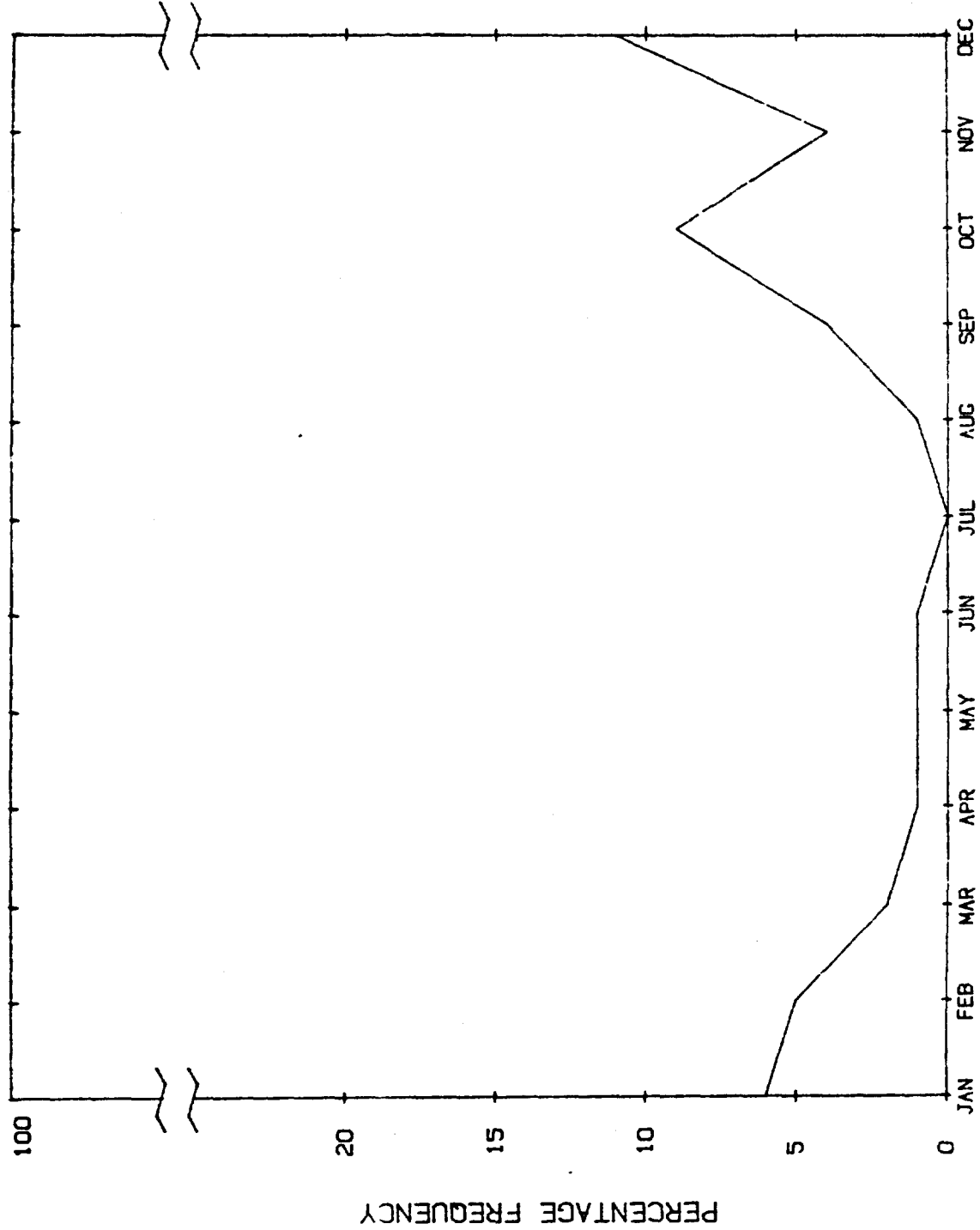


Figure A-212. Frequency of Occurrence Visibility < 300 Meters, Worst Case: Worldwide.

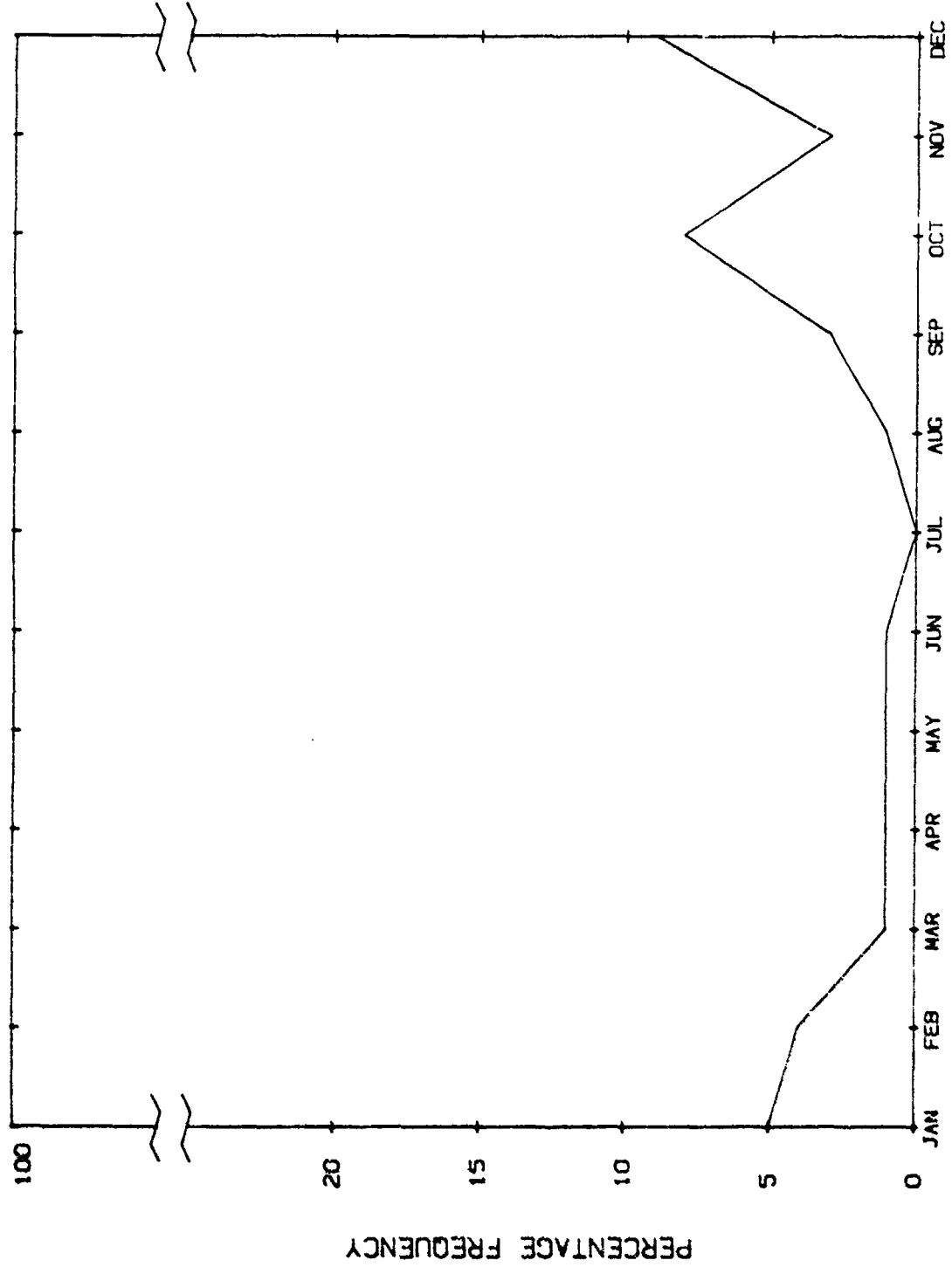


Figure A-213. Frequency of Occurrence Visibility < 200 Meters, Worst Case: Worldwide.

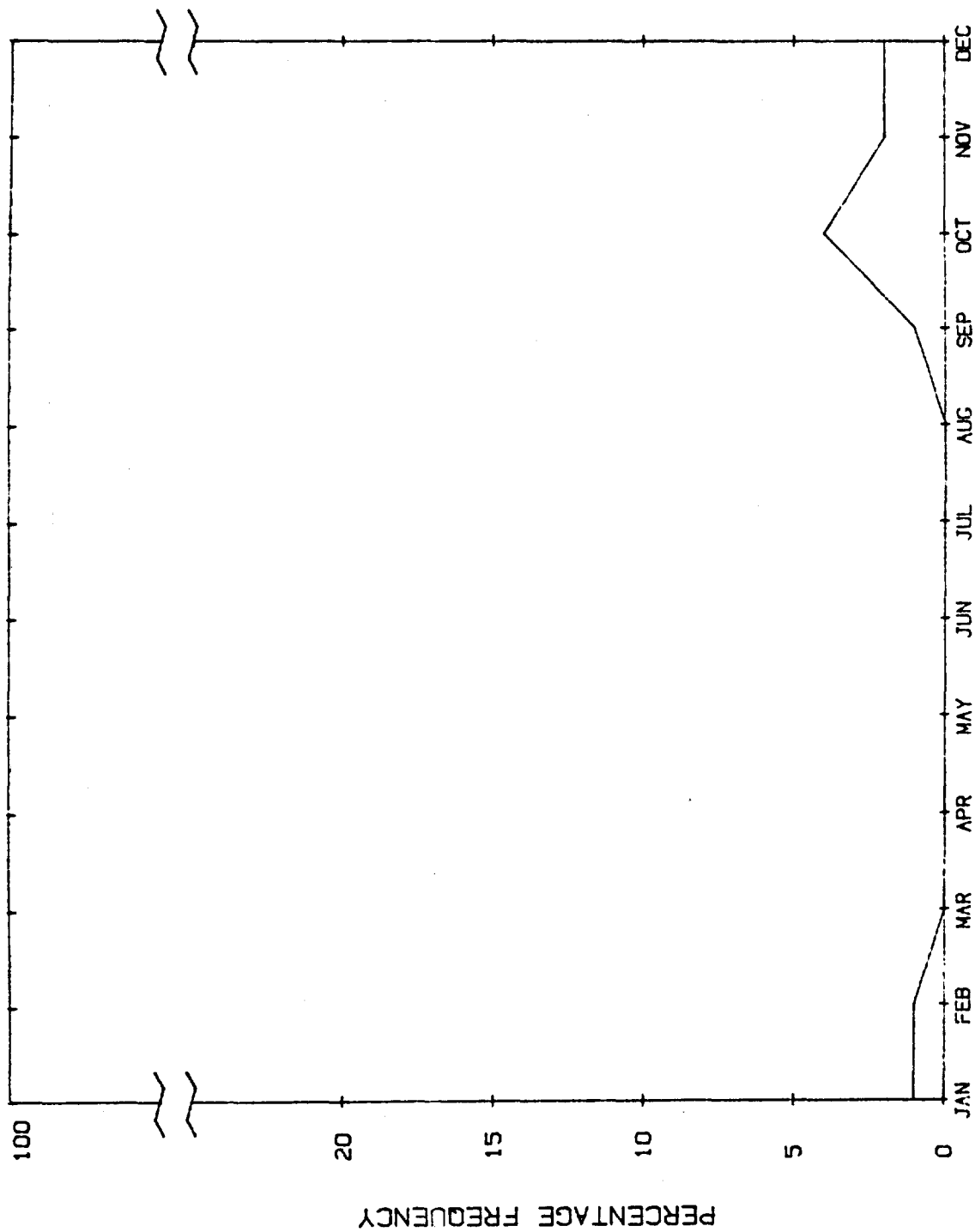


Figure A-214. Frequency of Occurrence Visibility < 100 Meters, Worst Case: Worldwide.

4. WIND AND WIND CHILL

Wind speeds are considered in this characterization, but not wind direction.

Wind chill is a biological index which is a function of the dry bulb temperature and the wind velocity. The wind chill can be calculated with the following equation:

$$K = ((v \times 100)^{\frac{1}{4}} - v + 10.5) \times (33 - t)$$

where

K = wind chill

v = wind velocity in m/sec

t = dry bulb temperature in °C.

a. Daily Peak Gusts

For each airbase in a theater, wind speed was recorded at hourly intervals. These data were combined into 24-hour groups and the maximum daily wind speed was determined. Daily peak gusts for each airbase were calculated by averaging the maximum daily wind speeds for each day in the month. These values were then averaged across the theater. The maximum of all airbases in the theater for every month was considered to be the worst case.

For each year in the period of record, maximum wind speeds were averaged. Each of these yearly means were then averaged to produce an annual mean maximum wind speed for each airbase. The annual mean gust for the theater was found by averaging the values for each airbase in the theater.

EXAMPLE: In November at Upper Heyford, the average daily peak gust was approximately 42 knots (Figure A-215). The mean annual gust of 51 knots represents the average of the annual maximum wind speeds over every recorded year.

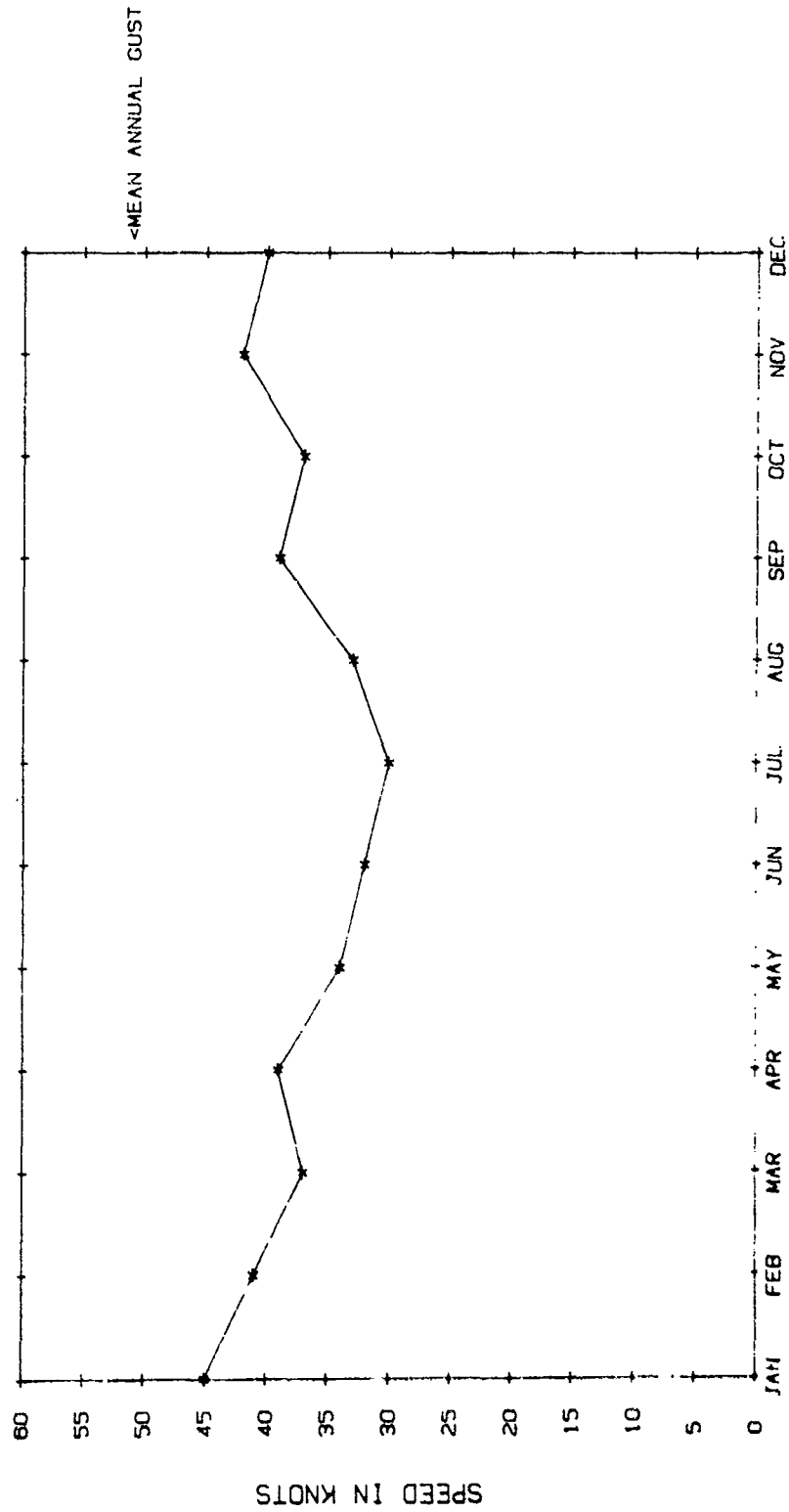


Figure A-215. Daily Peak Gusts, Upper Heyford.

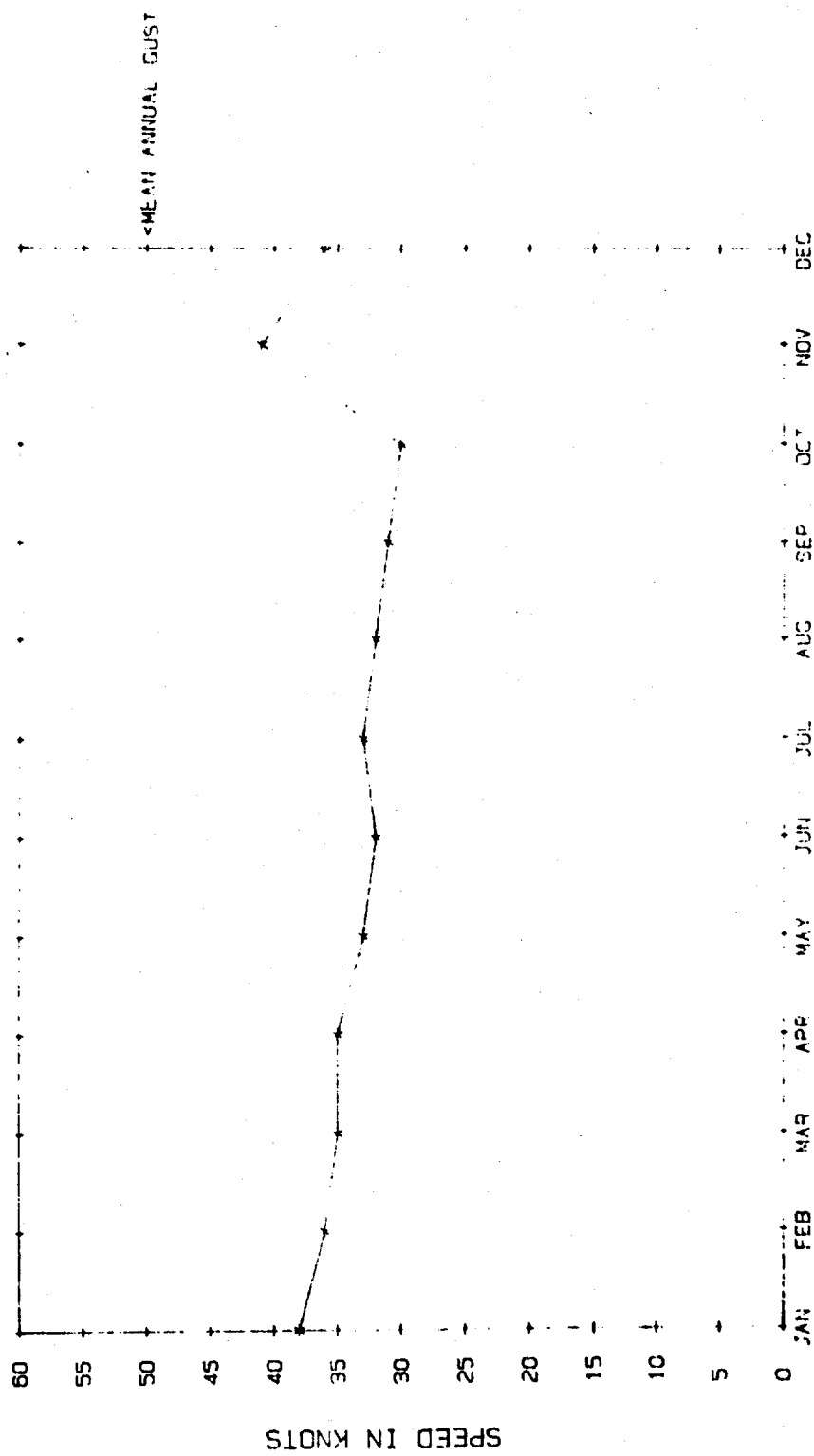


Figure A-216. Daily Peak Gusts, Mean of German Airbases.

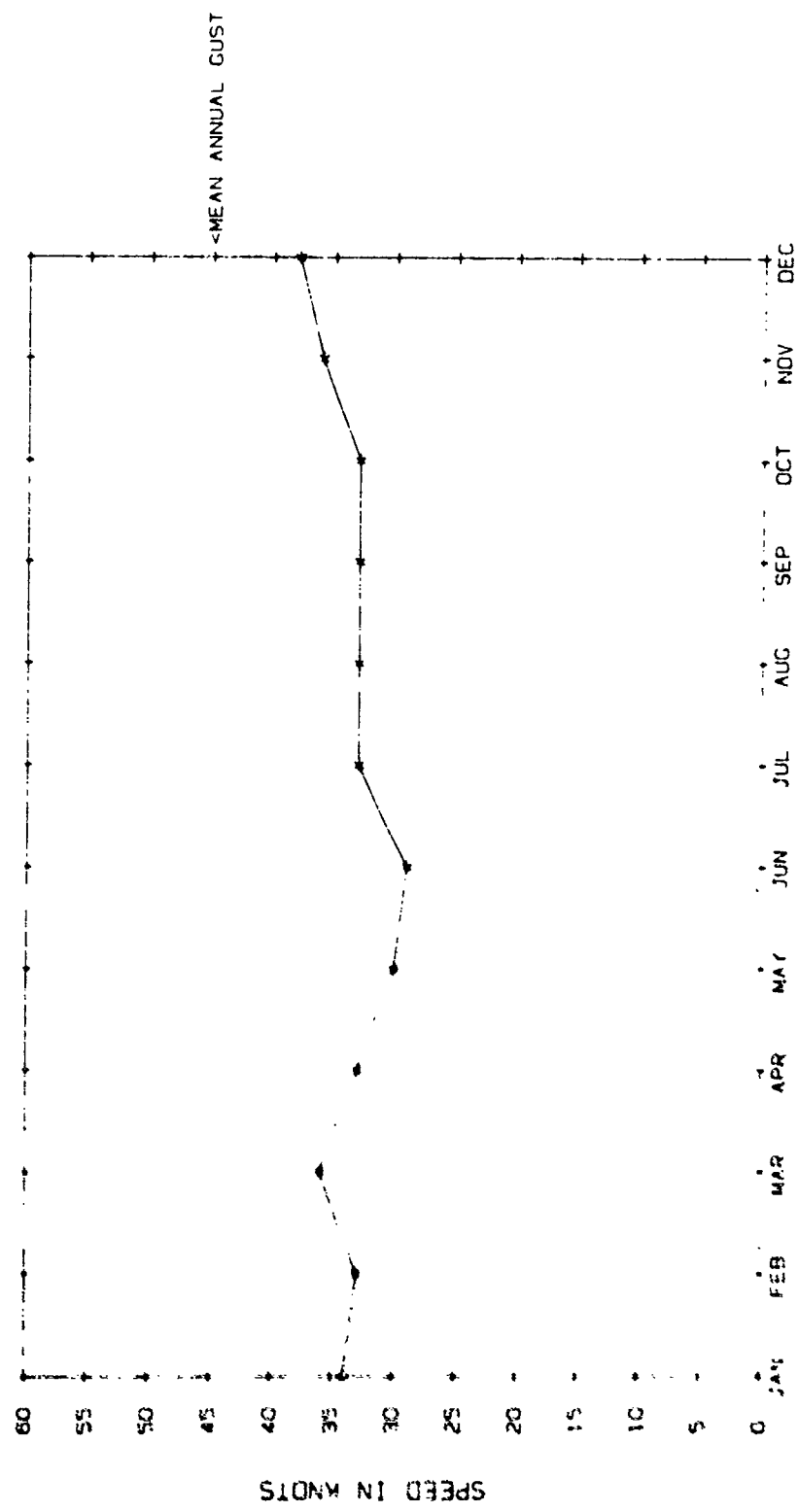


Figure A-217. Daily Peak Gusts, Korea: Mean of Osan and Kunsan.

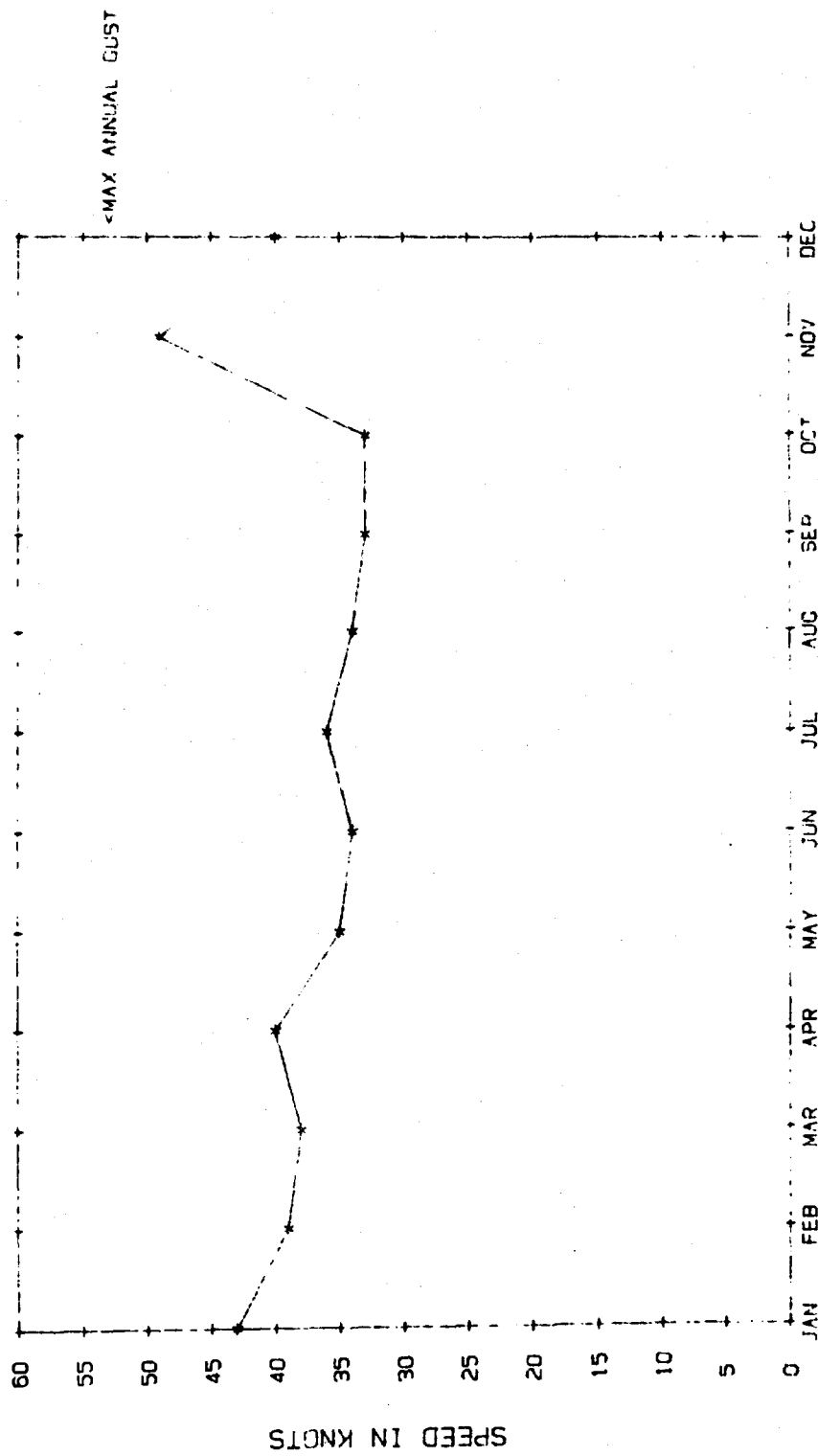


Figure A-218. Daily Peak Gusts, Worst Case: Germany.

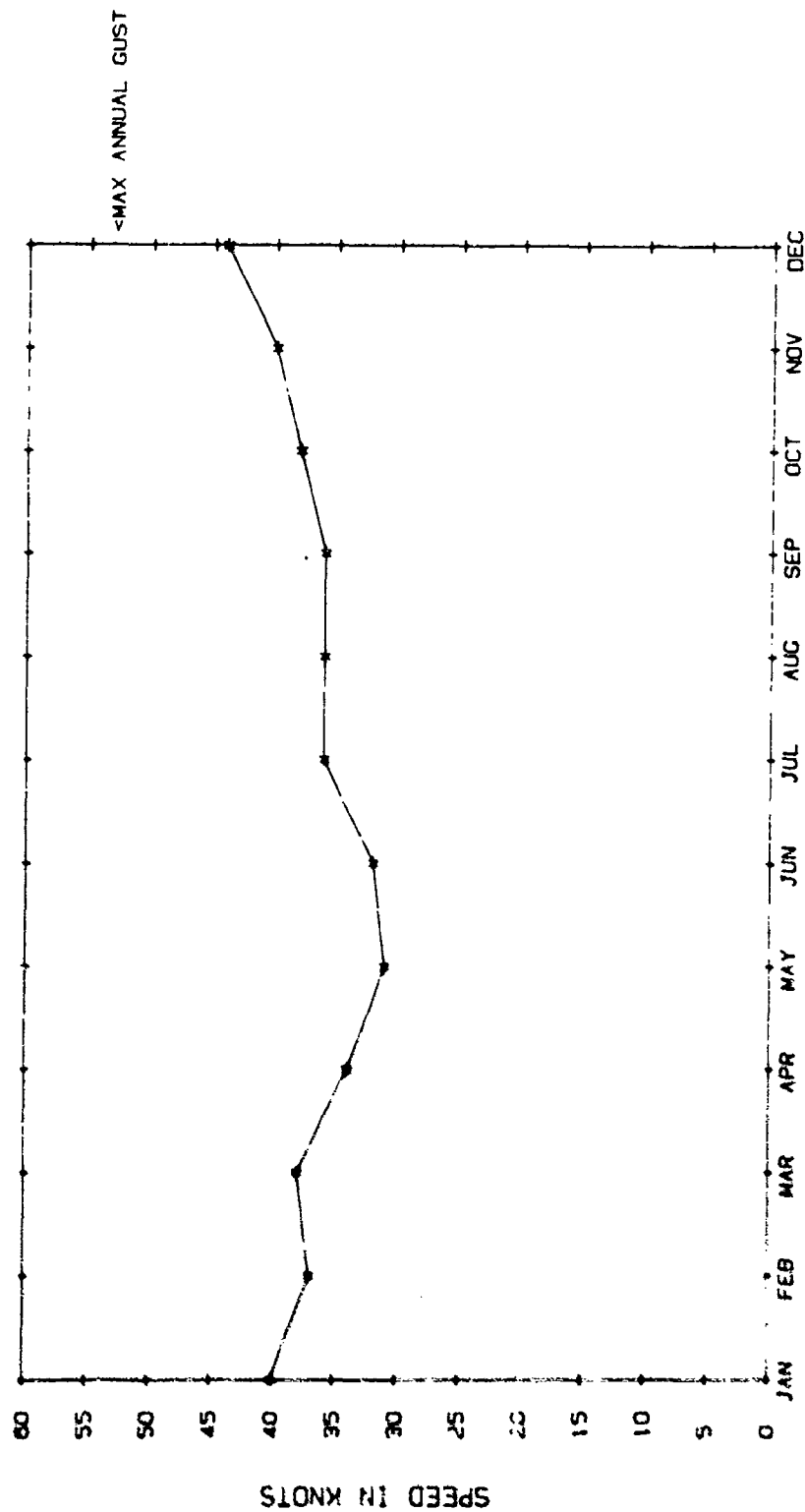


Figure A-219. Daily Peak Gusts, Worst Case: Korea.

b. Ninety-Ninth Percentile Wind Chill Temperatures

Wind chill temperatures were recorded at hourly intervals throughout the period of record. For each of the given airbases, 99 percent of all wind chill temperatures recorded are greater than the value given (Table A-3).

EXAMPLE: At Hahn Air Base, only 1 percent of the wind chill temperatures measured throughout the year are less than -2.2°F .

TABLE A-3. NINETY-NINTH PERCENTILE WIND CHILL TEMPERATURE

UPPER HEYFORD	15.8	⁰ F
HAHN	- 2.2	⁰ F
RAMSTEIN	6.8	⁰ F
KUNSAN	- 2.2	⁰ F
USAN	-11.2	⁰ F

c. Frequency of Occurrence of Wind Speeds

For each airbase in a theater, wind velocity was measured and recorded at hourly intervals. The frequency of occurrence of wind velocity within the various ranges indicated on the graphs was calculated from these data. These values were then grouped by month or annually and averaged across the theater. The highest wind velocity recorded for each interval for each of the airbases within a theater was considered to be the worst case.

EXAMPLE: Annually, Upper Heyford experiences 7-10 knot winds in approximately 31 percent of the hourly observations recorded (Figure A-220).

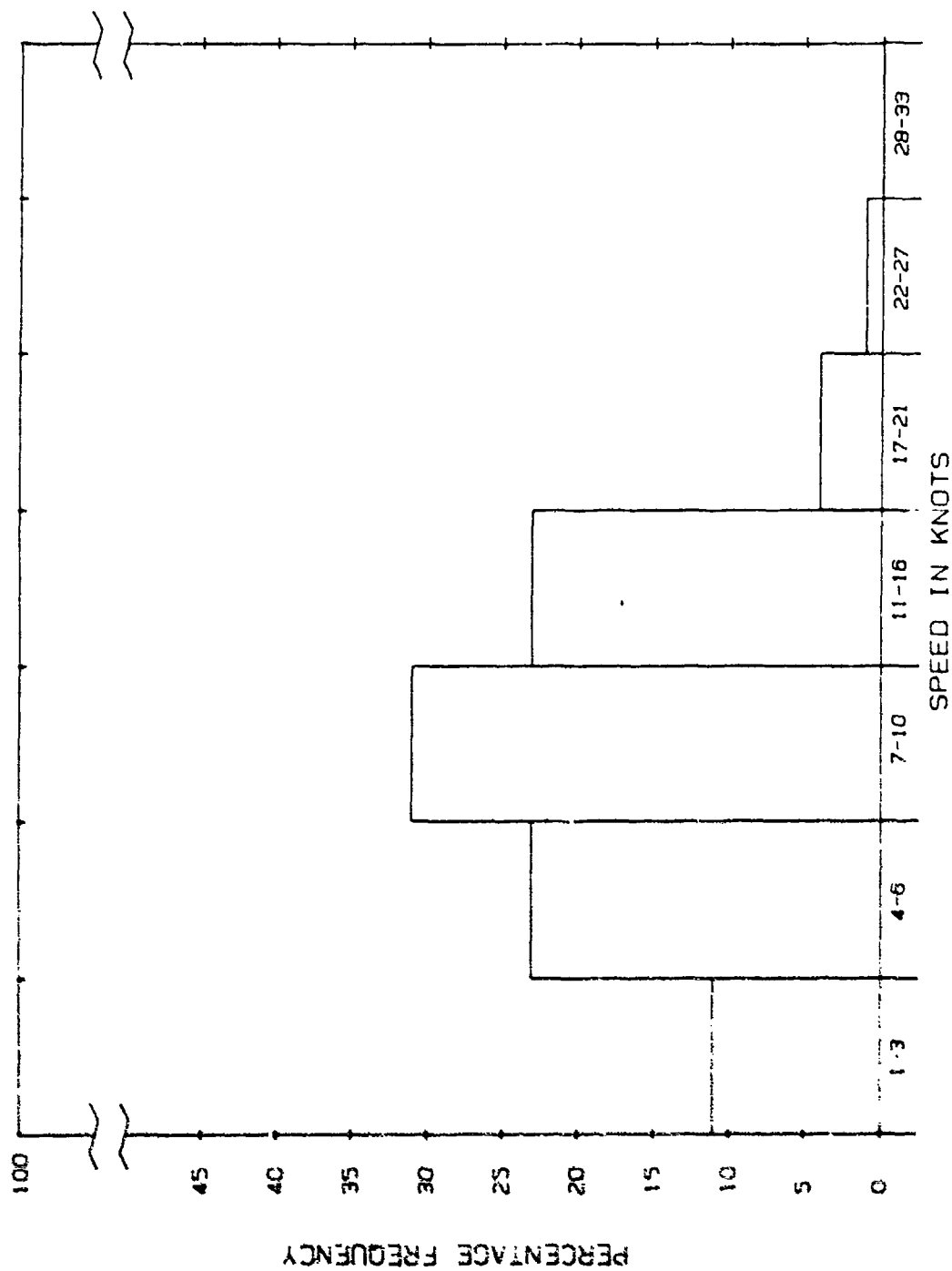


Figure A-220. Annual Frequency of Occurrence of Wind Speeds, Upper Heyford.

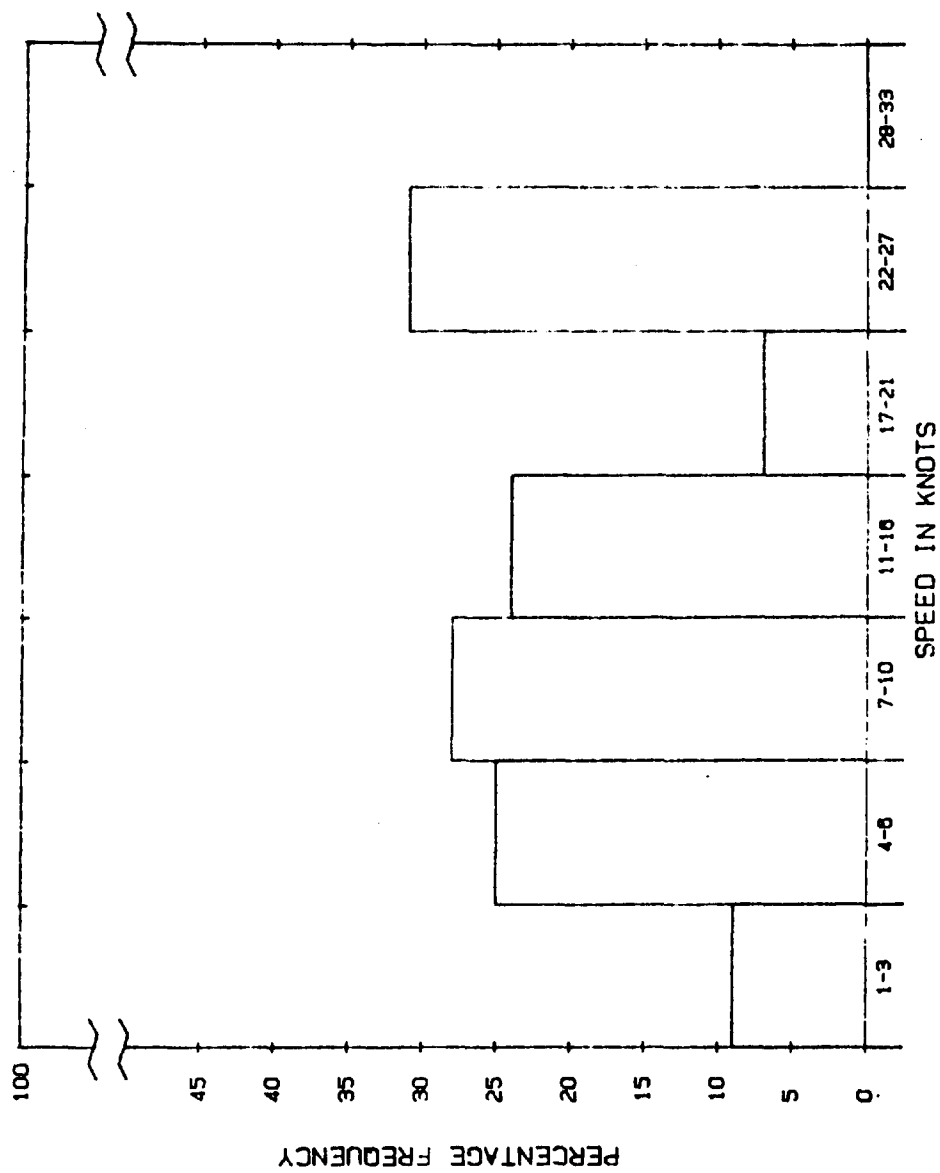


Figure A-221. Frequency of Occurrence of Wind Speeds, Upper Heyford in January.

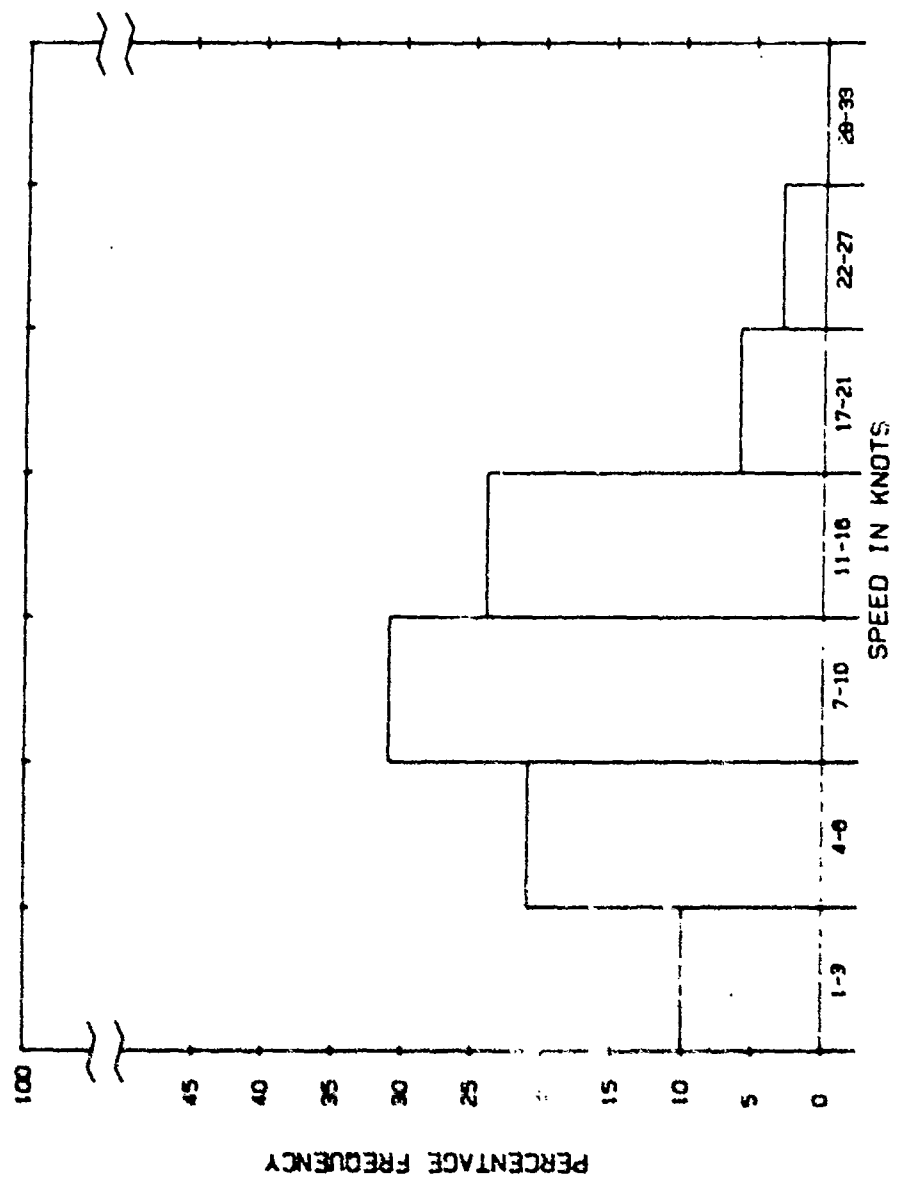


Figure A-222. Frequency of Occurrence of Wind Speeds, Upper Heyford in February.

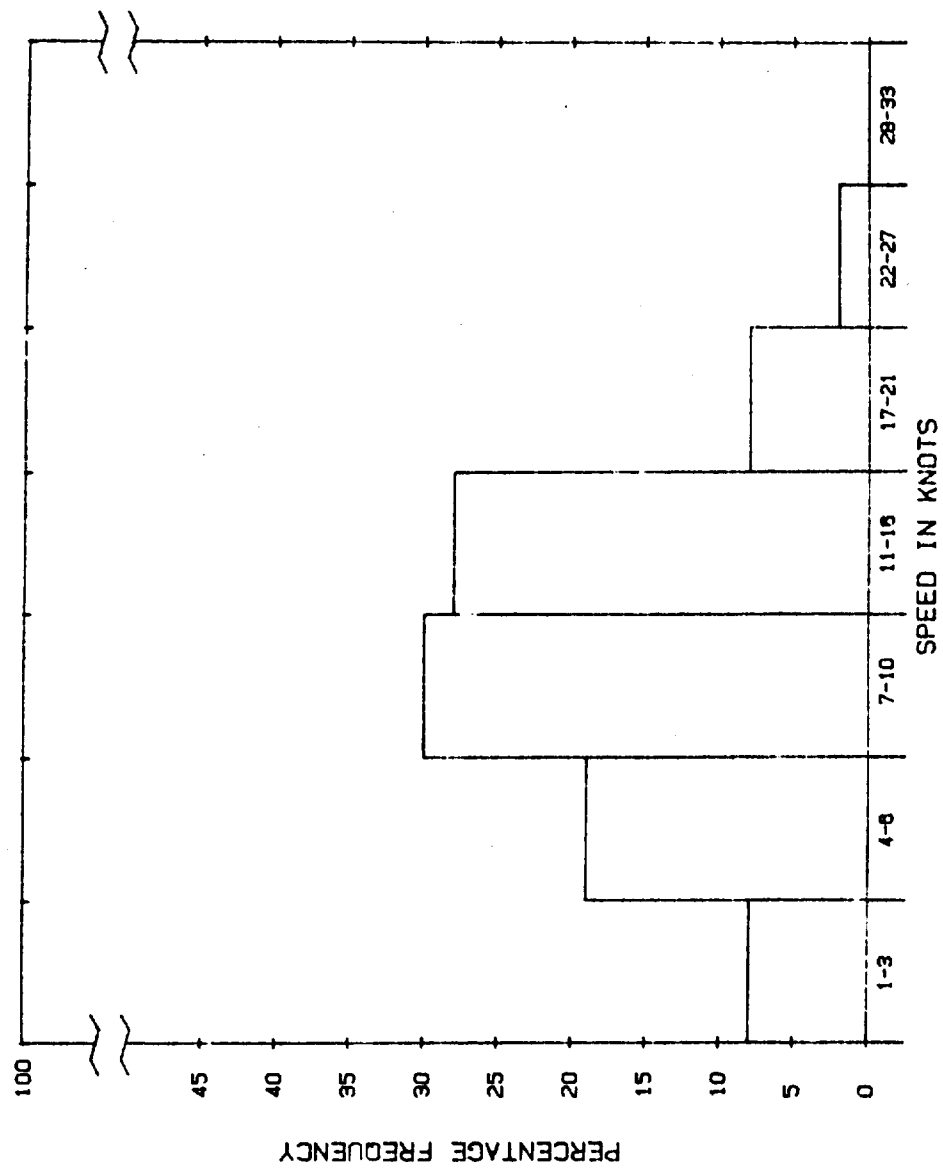


Figure A-223. Frequency of Occurrence of Wind Speeds, Upper Heyford in March.

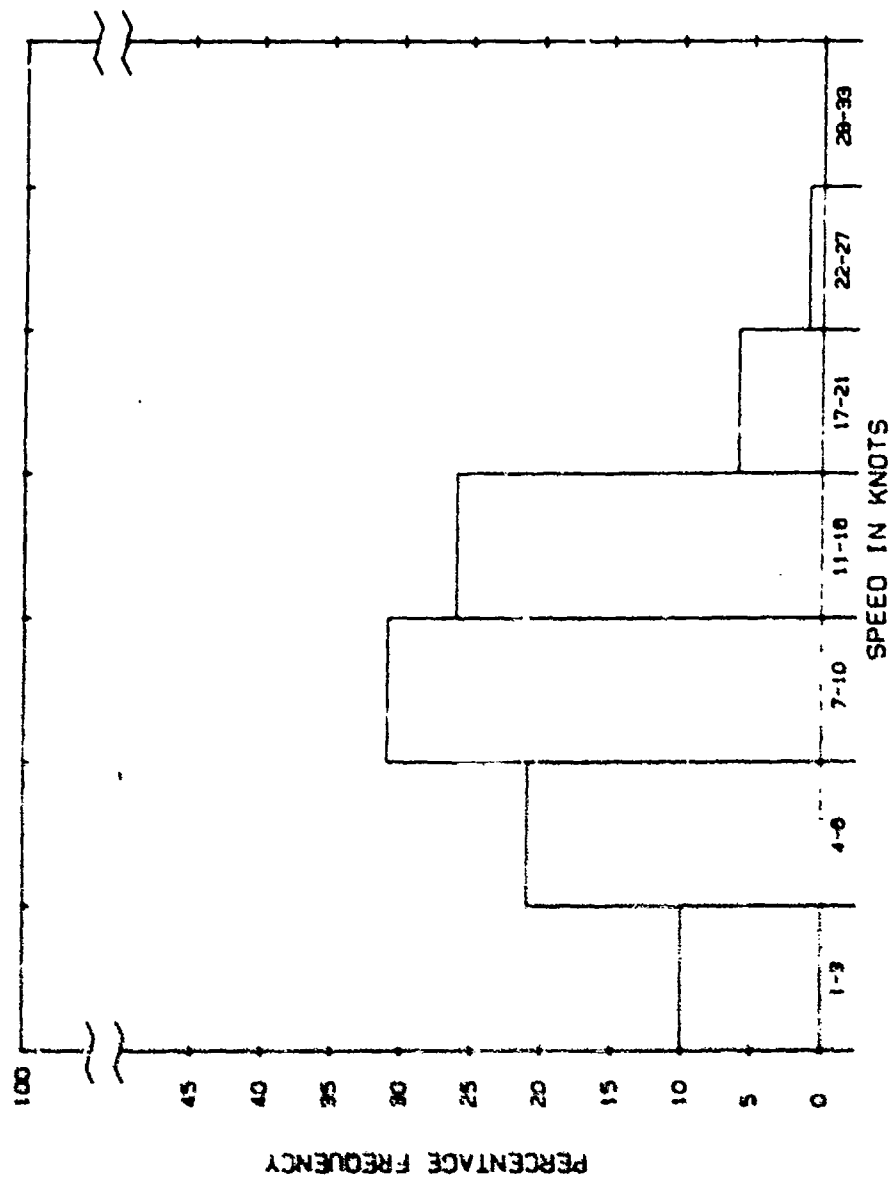


Figure A-22a. Frequency of Occurrence of Wind Speeds, Upper Heyford in April.

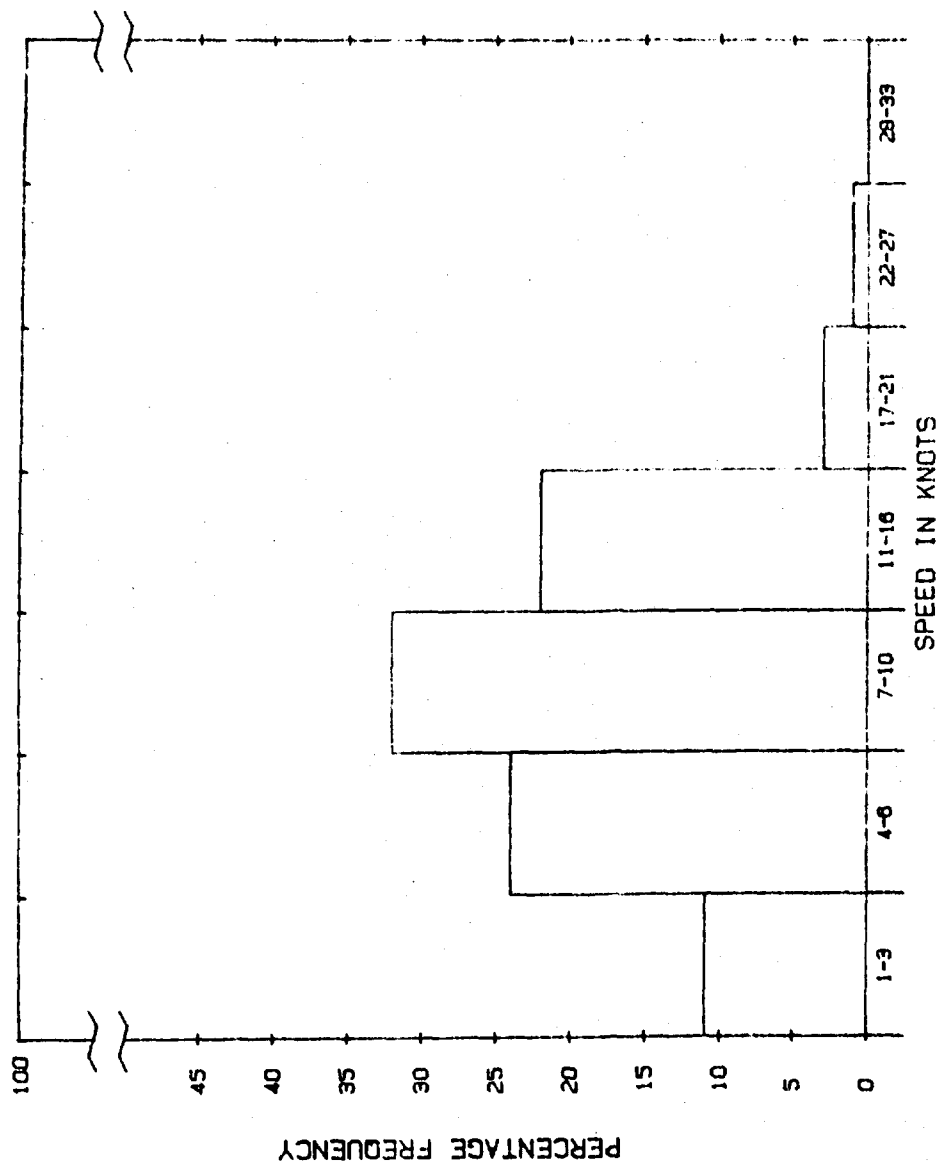


Figure A-225. Frequency of Occurrence of Wind Speeds, Upper Heyford in May.

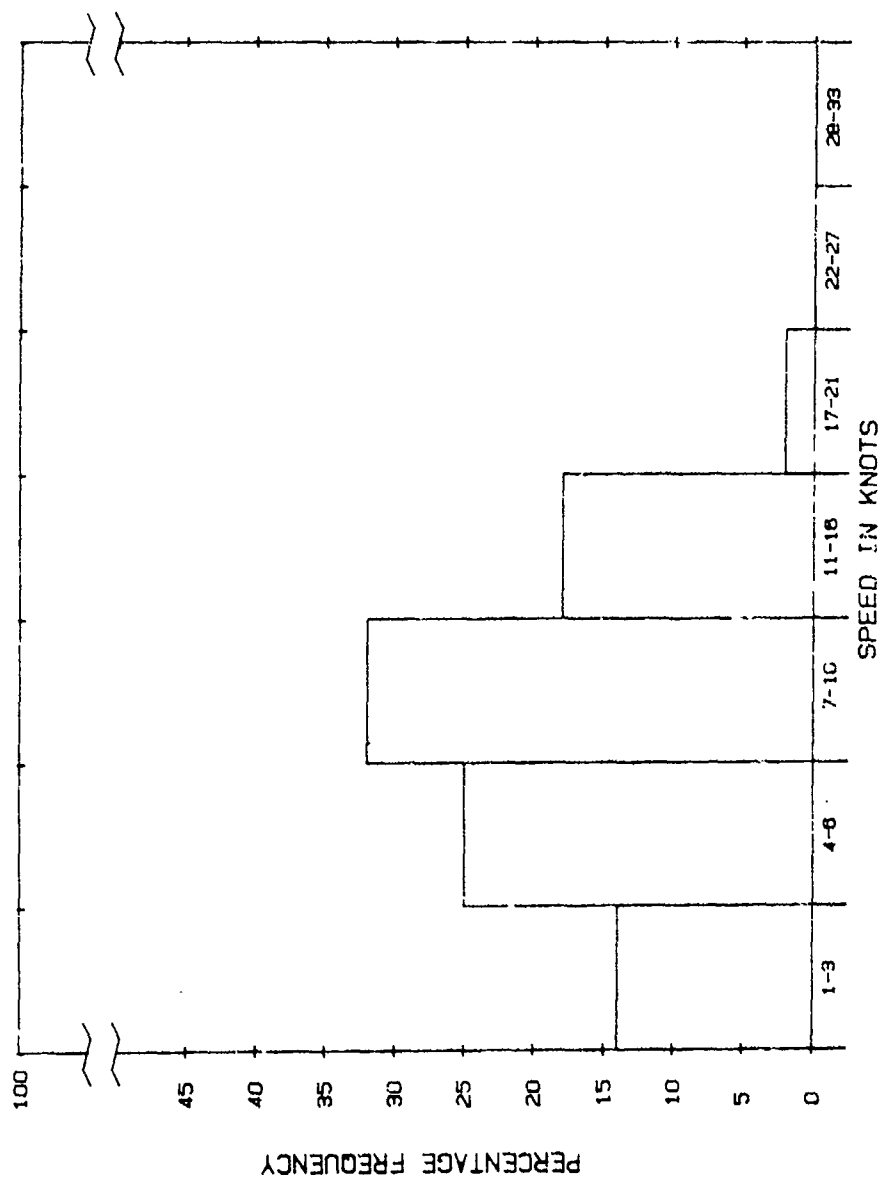


Figure A-226. Frequency of Occurrence of Wind Speeds, Upper Heyford in June.

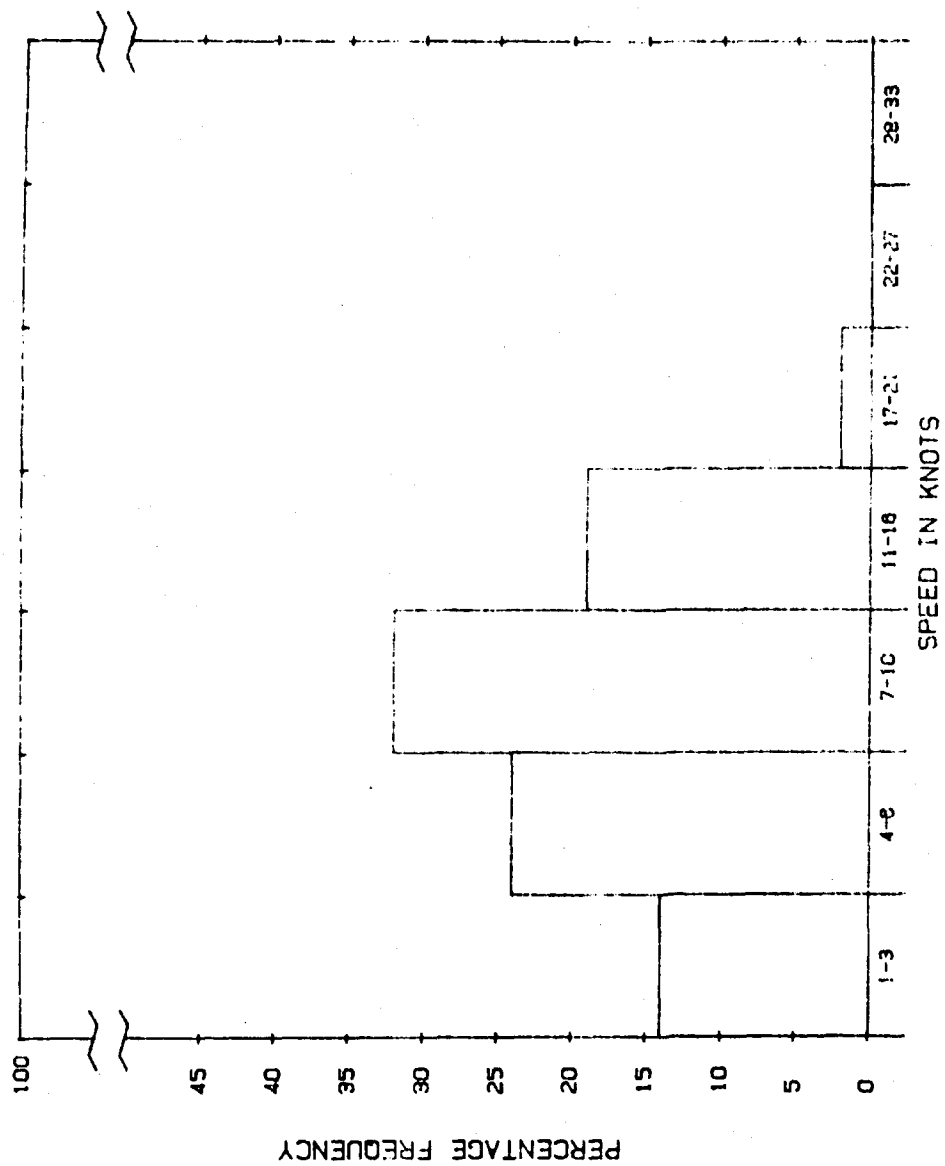


Figure A-227. Frequency of Occurrence of Wind Speeds, Upper Heyford in July.

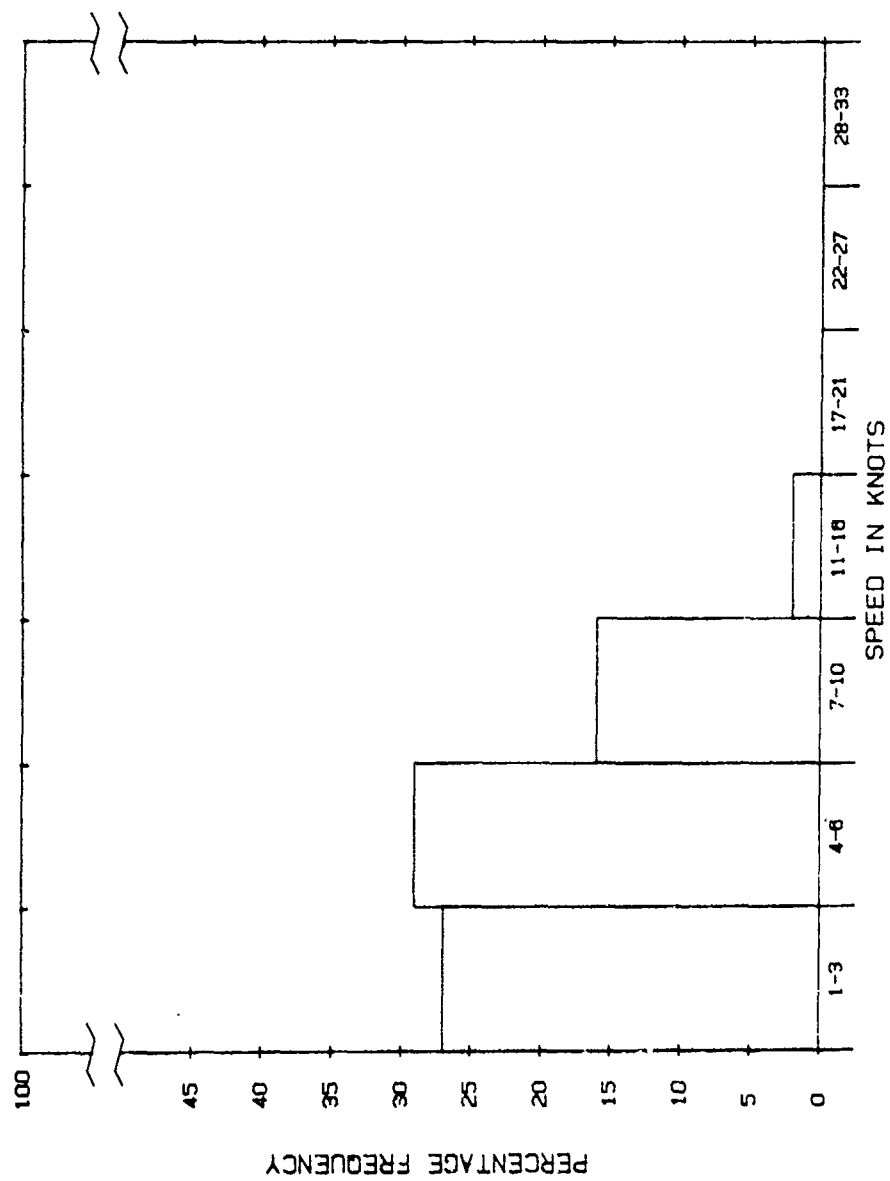


Figure A-228. Frequency of Occurrence of Wind Speeds, Upper Heyford in August.

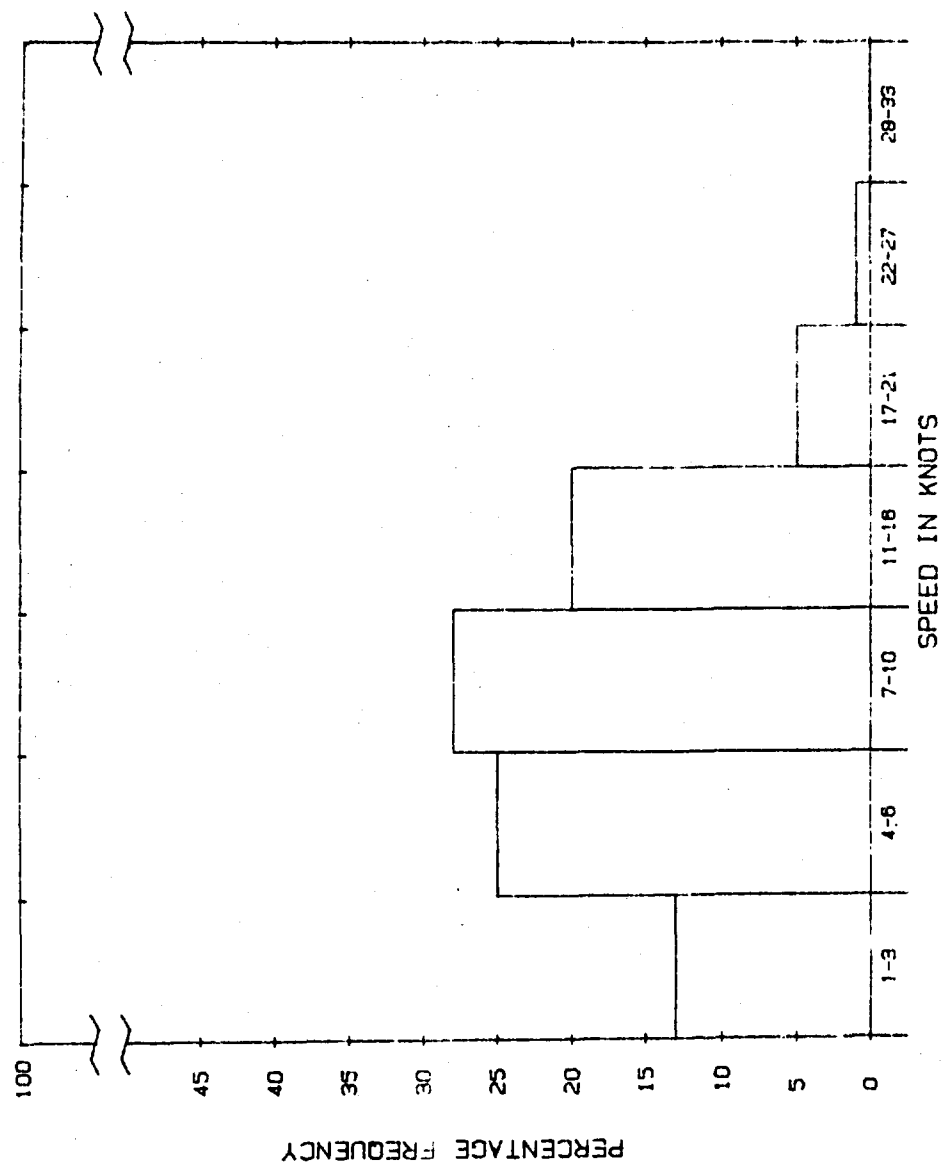


Figure A-229. Frequency of Occurrence of Wind Speeds, Upper Heyford in September.

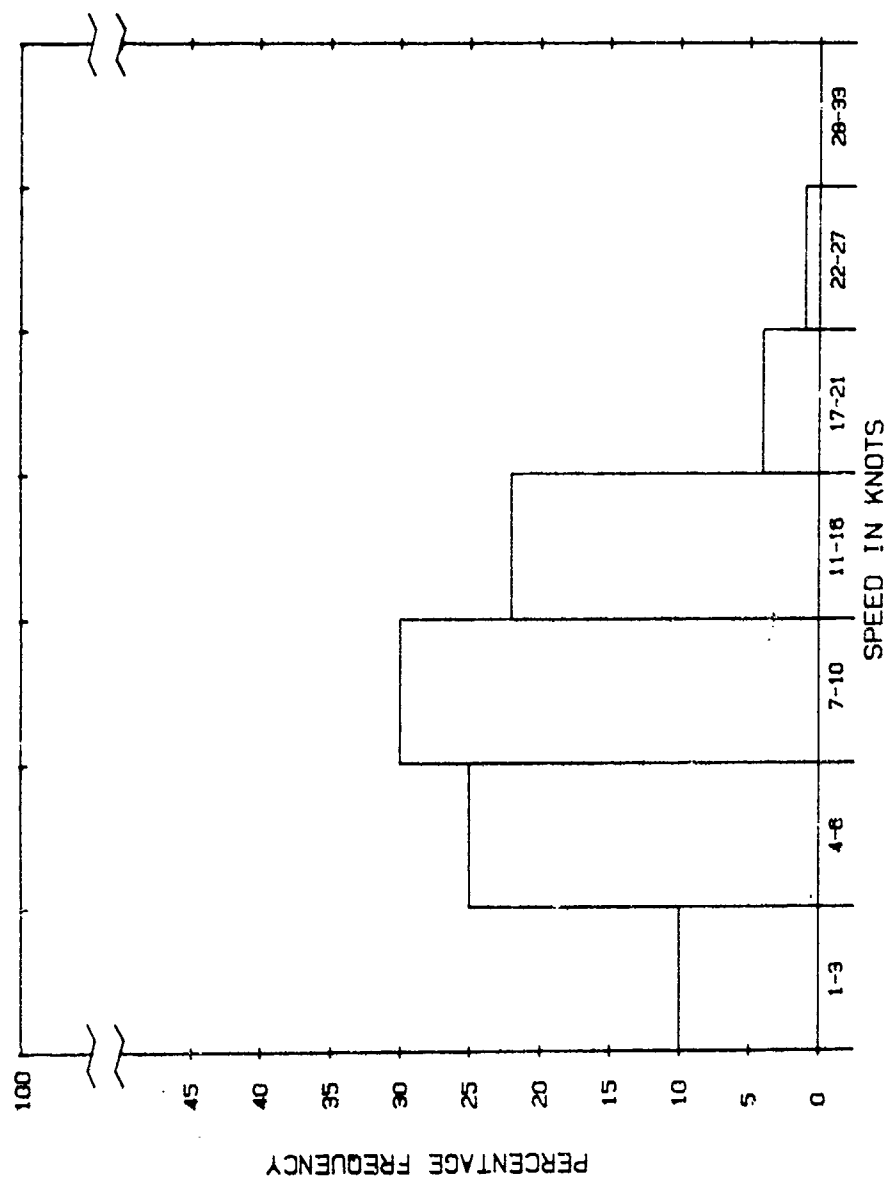


Figure A-230. Frequency of Occurrence of Wind Speeds, Upper Heyford in October.

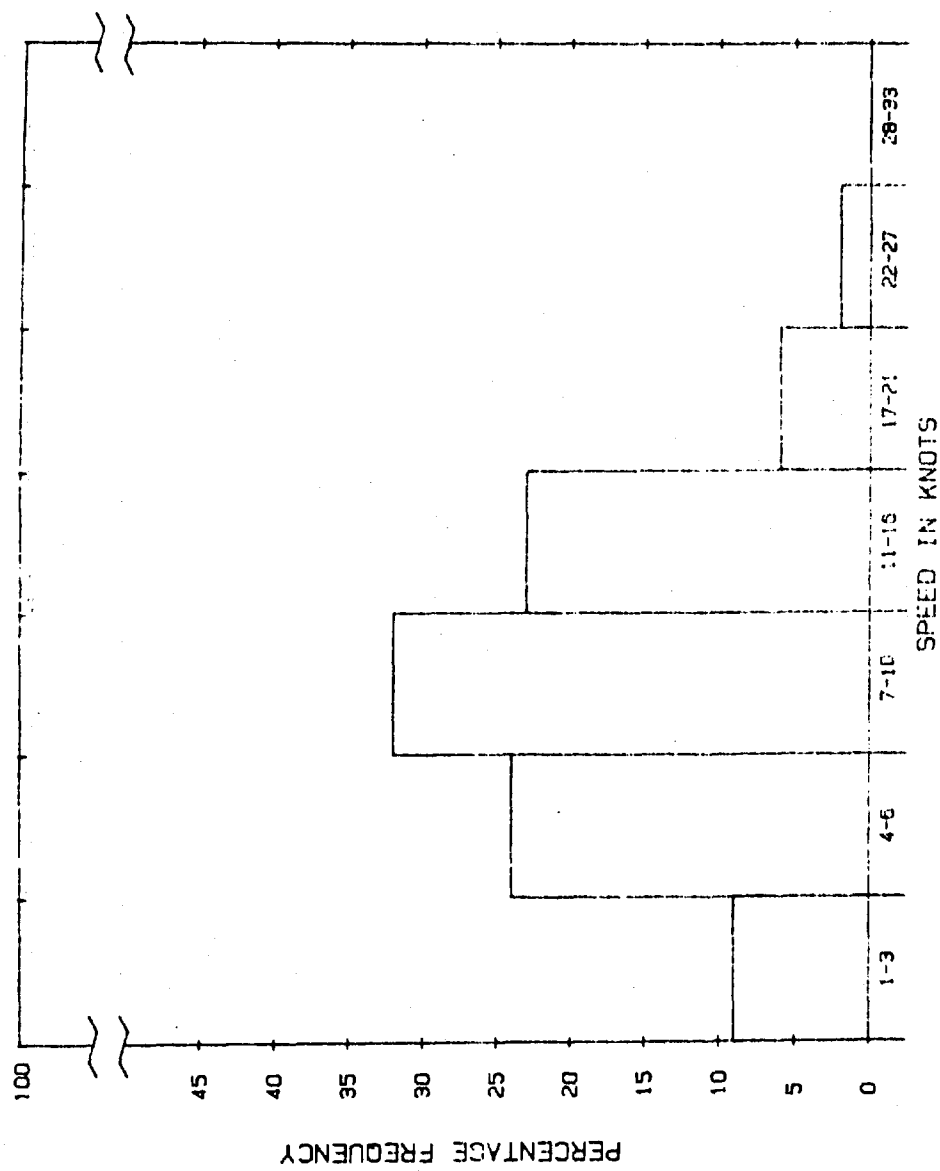


Figure A-231. Frequency of Occurrence of Wind Speeds. Upper Heyford in November.

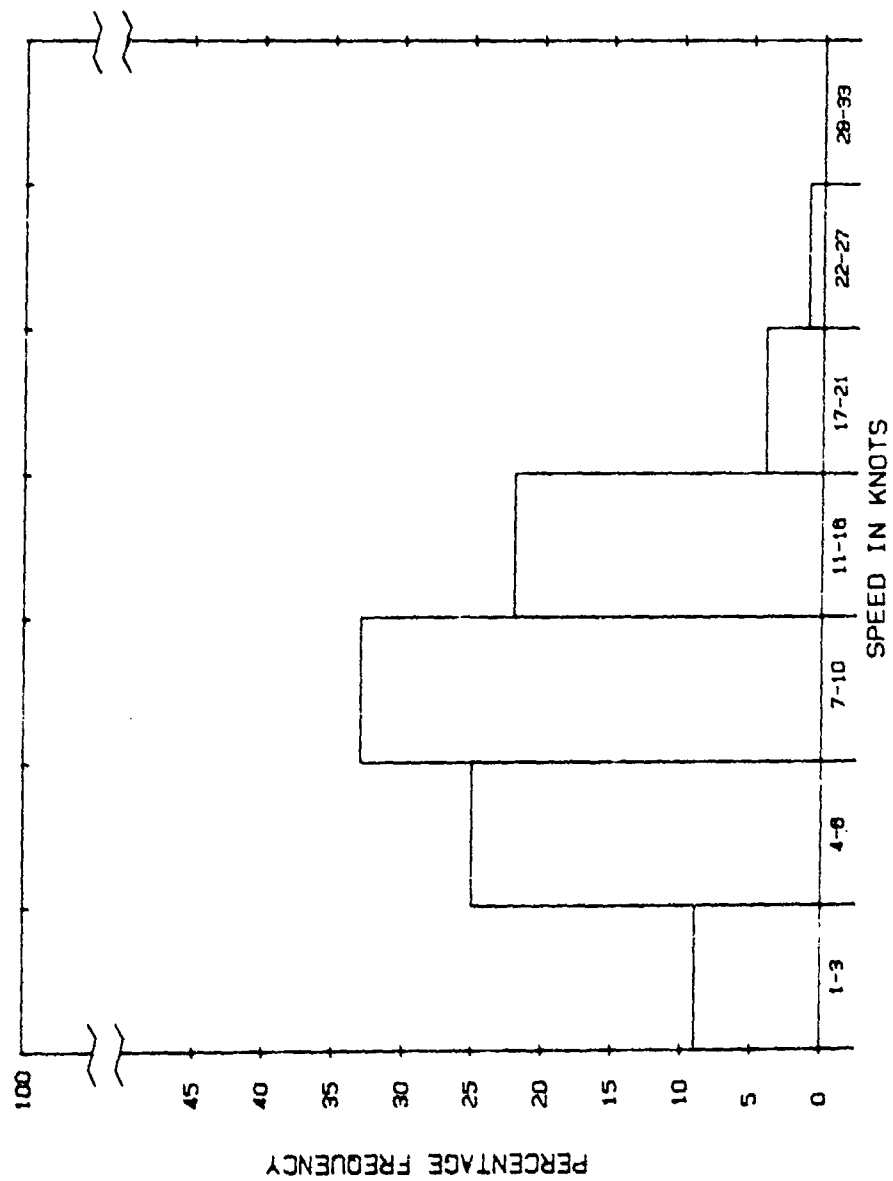


Figure A-232. Frequency of Occurrence of Wind Speeds, Upper Heyford in December.

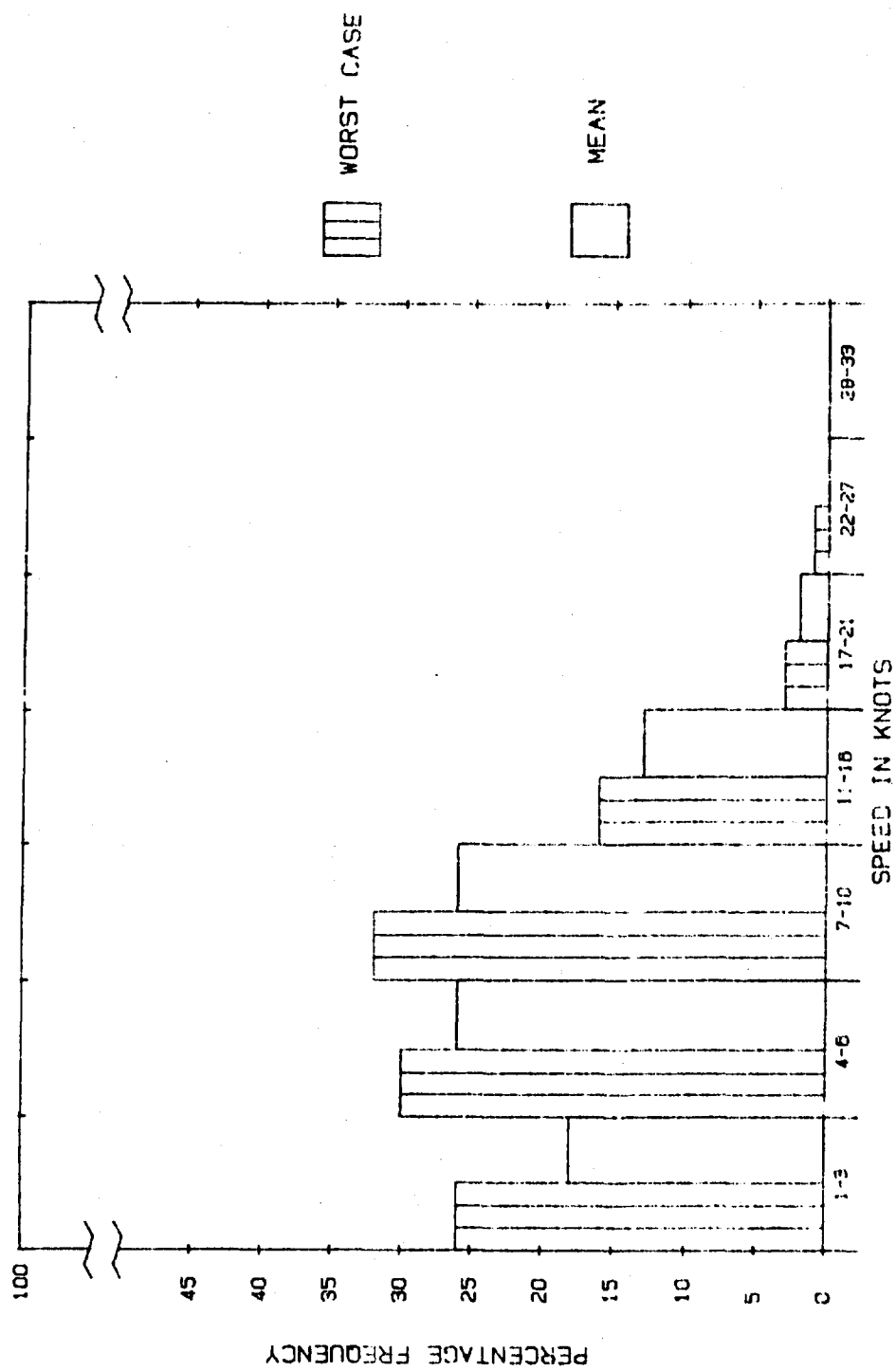


Figure A-233. Annual Frequency of Occurrence of Wind Speeds, Germany.

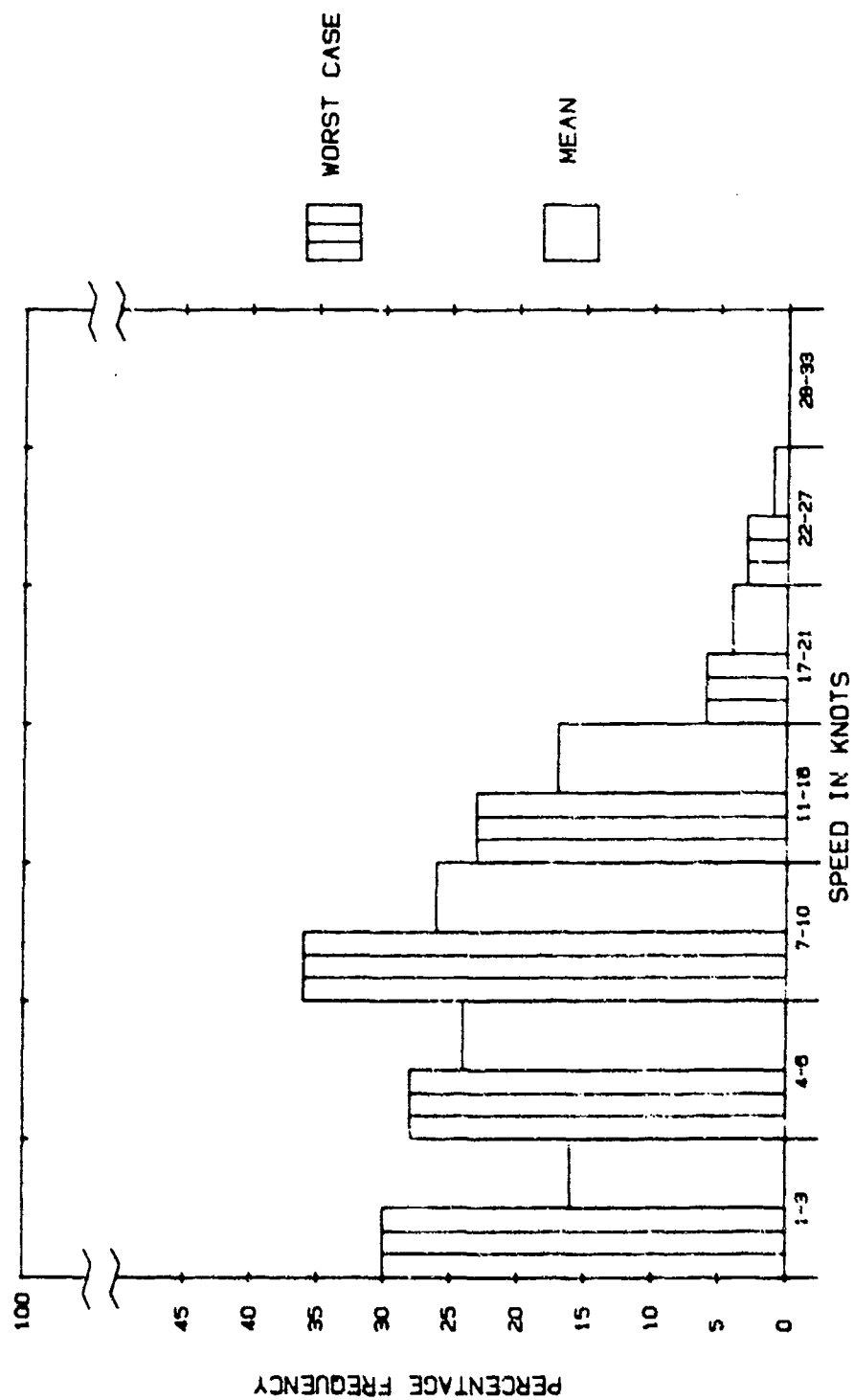


Figure A-234. Frequency of Occurrence of Wind Speeds, Germany in January.

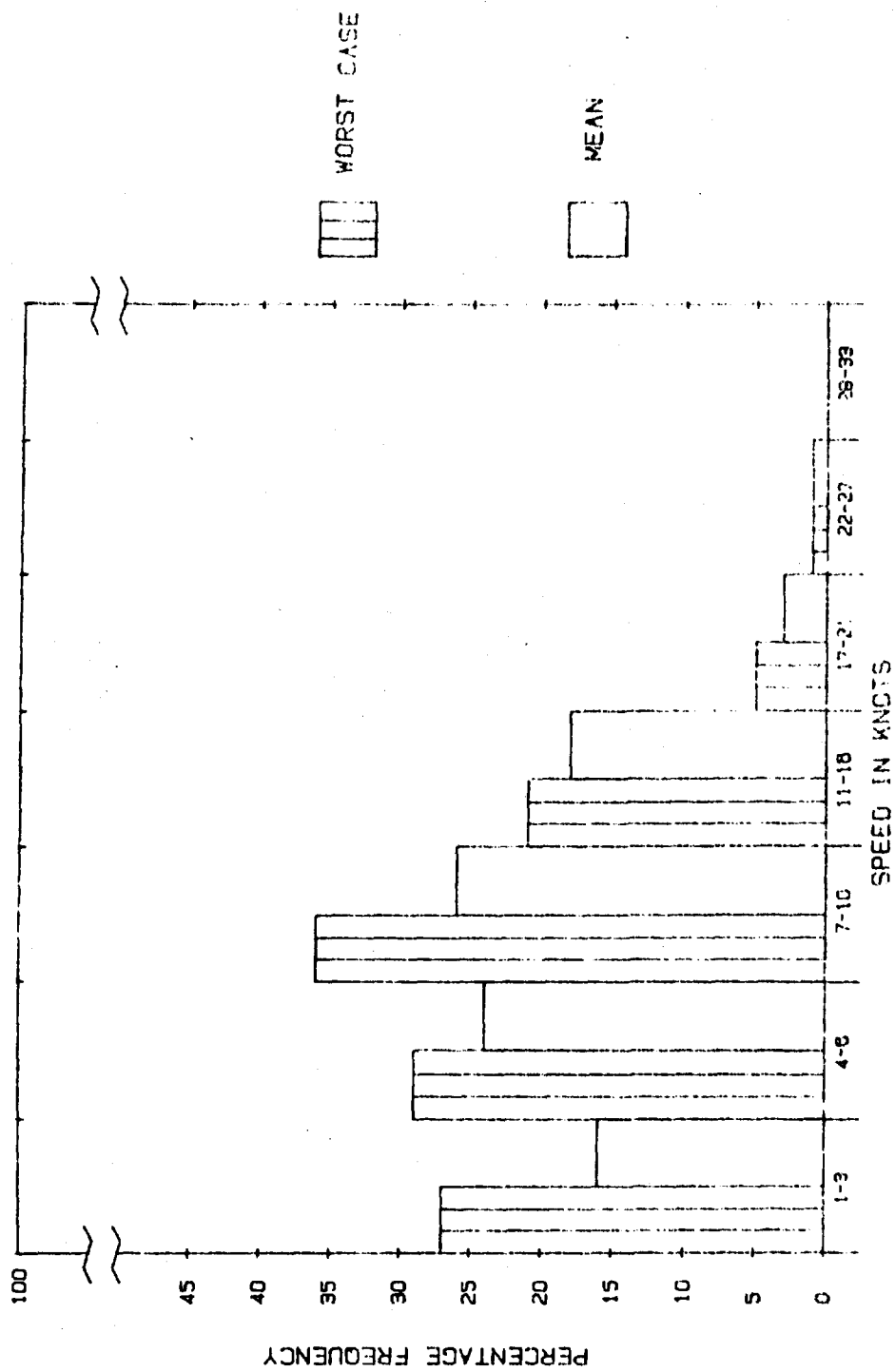


Figure 6-205. Frequency of occurrence of wind speeds, Germany in February.

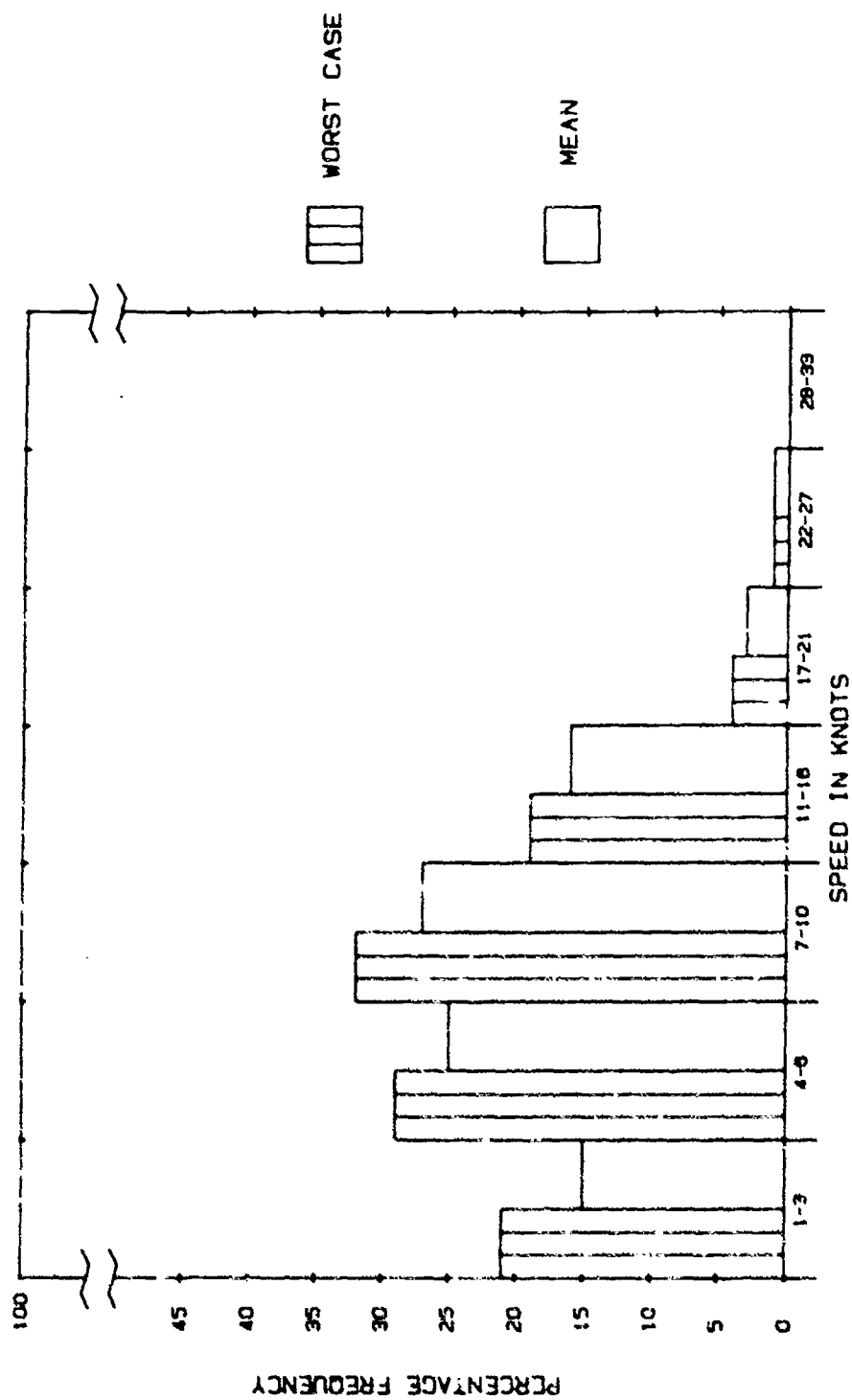


Figure A-236. Frequency of Occurrence of Wind Speeds, Germany in March.

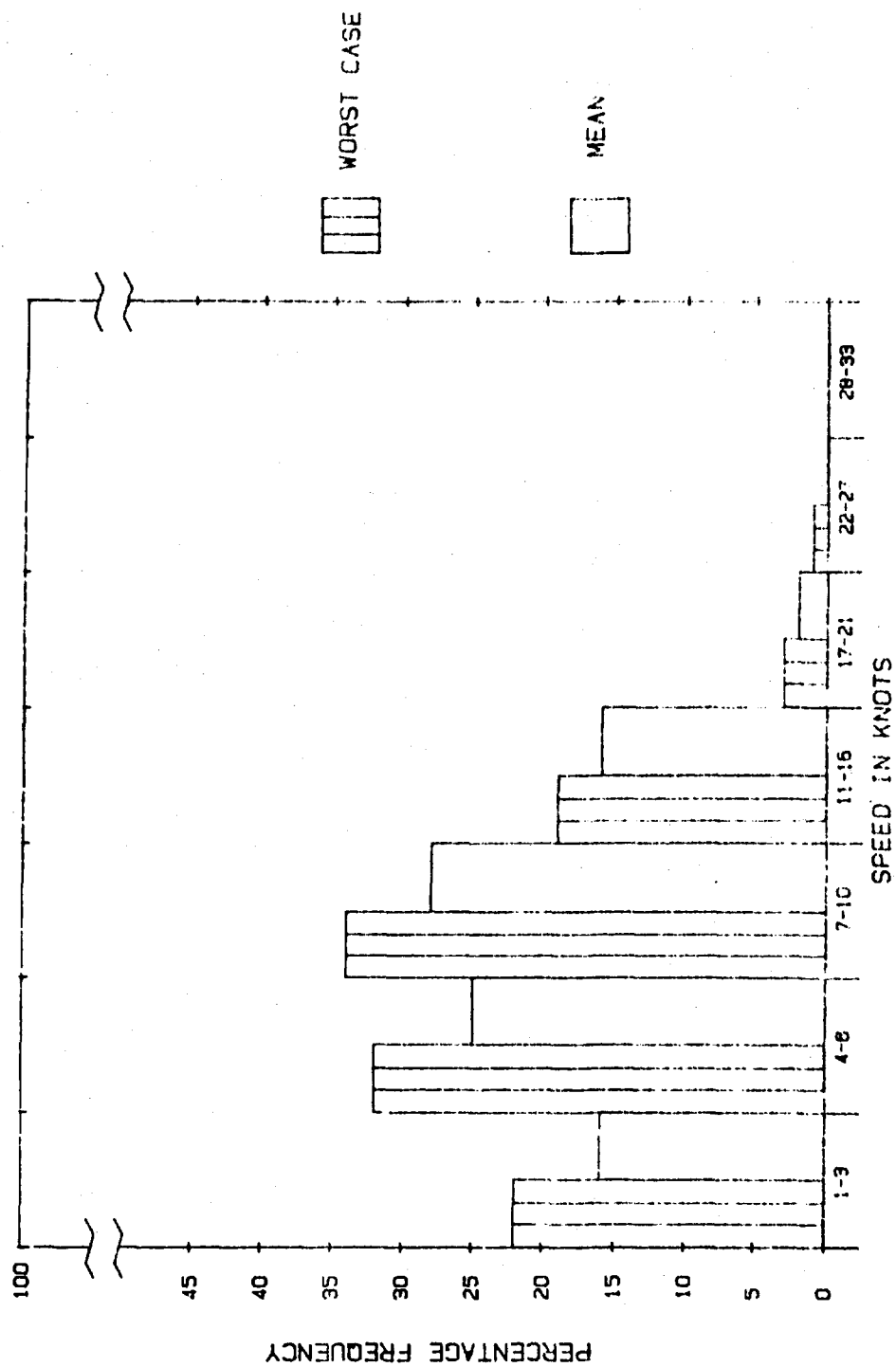


Figure A-237. Frequency of Occurrence of Wind Speeds, Germany in April.

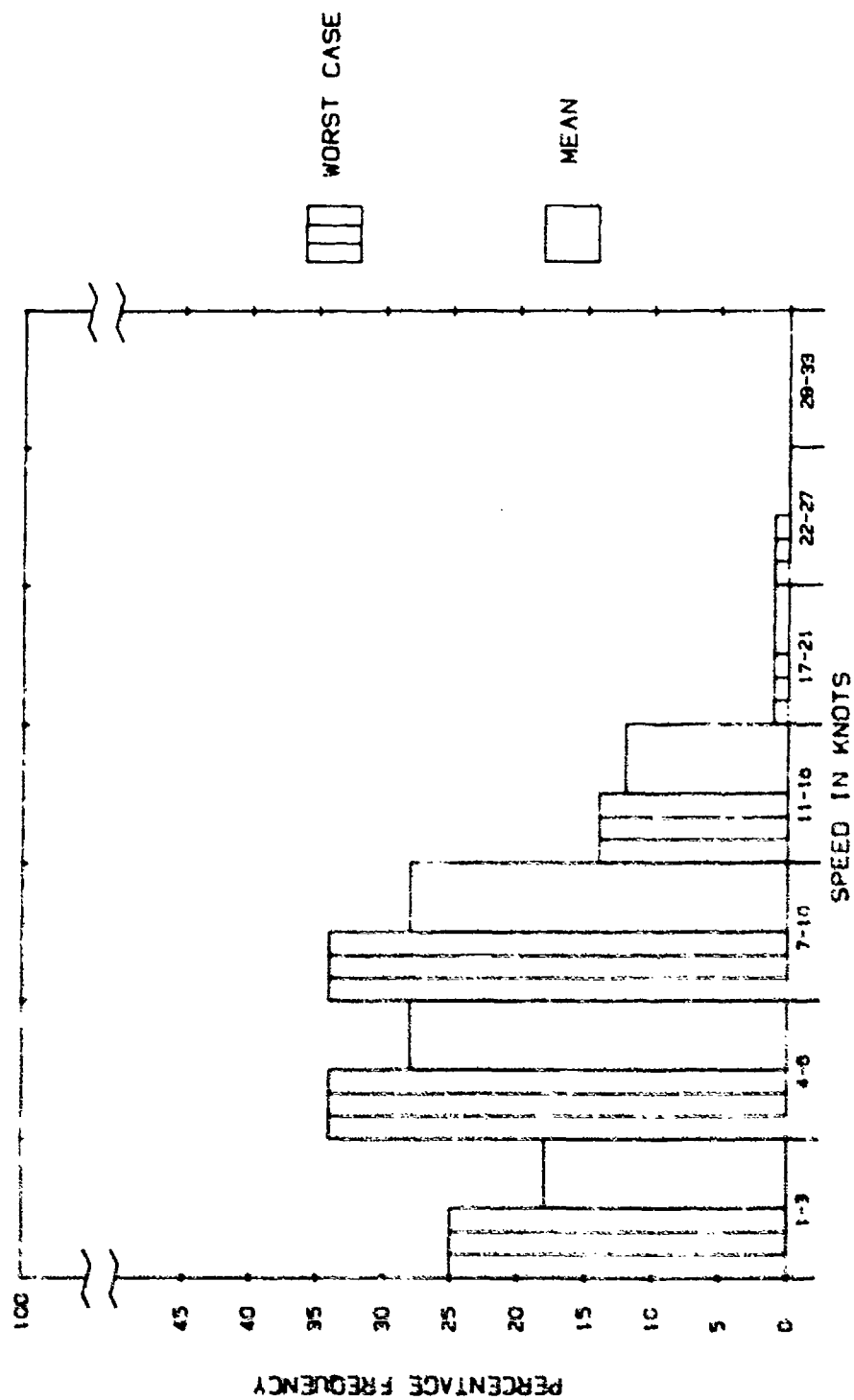


Figure A-238. Frequency of Occurrence of Wind Speeds, Germany in May.

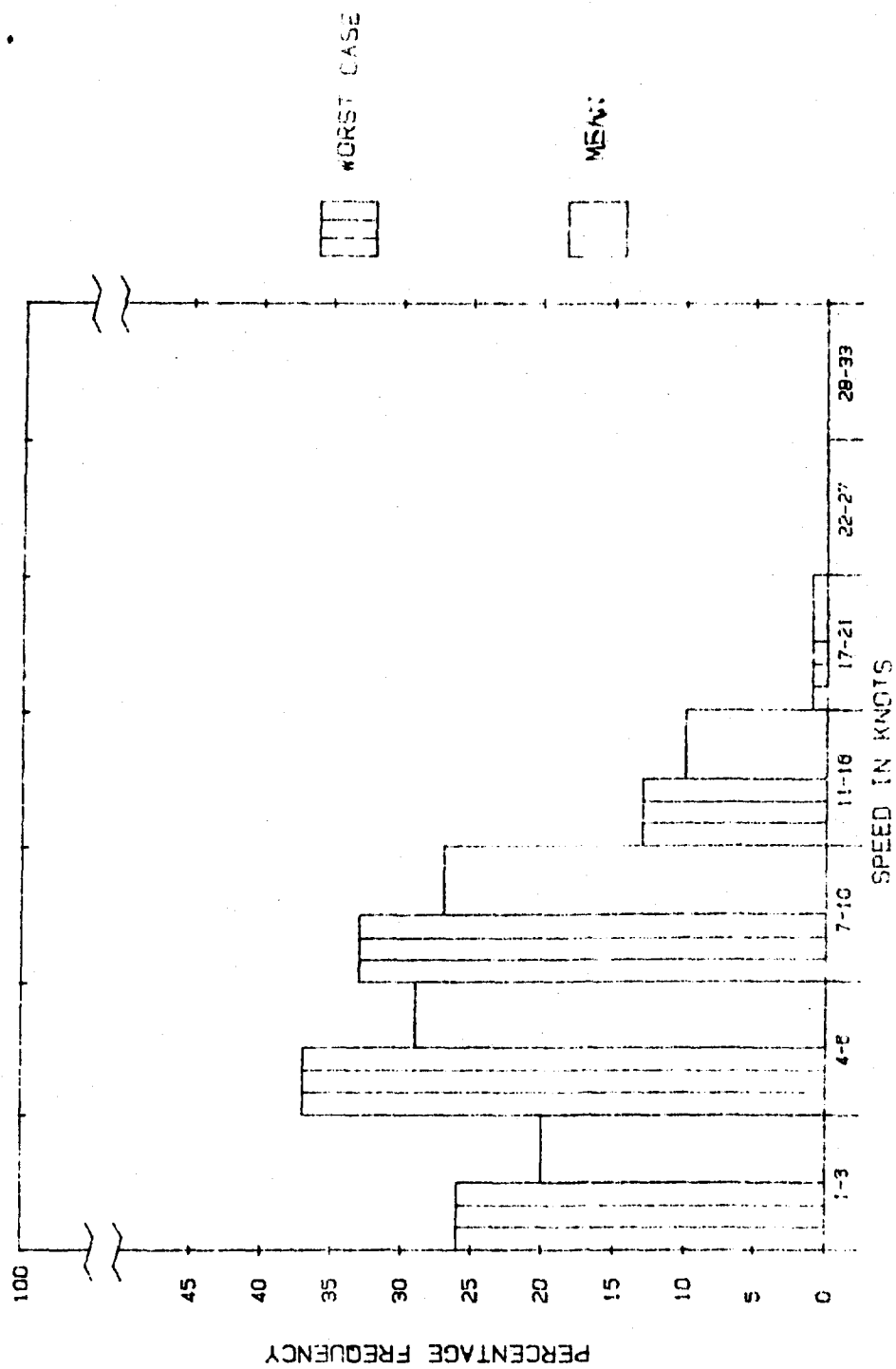


Figure A-239. Frequency of Occurrence of Wind Speeds, Germany in June.

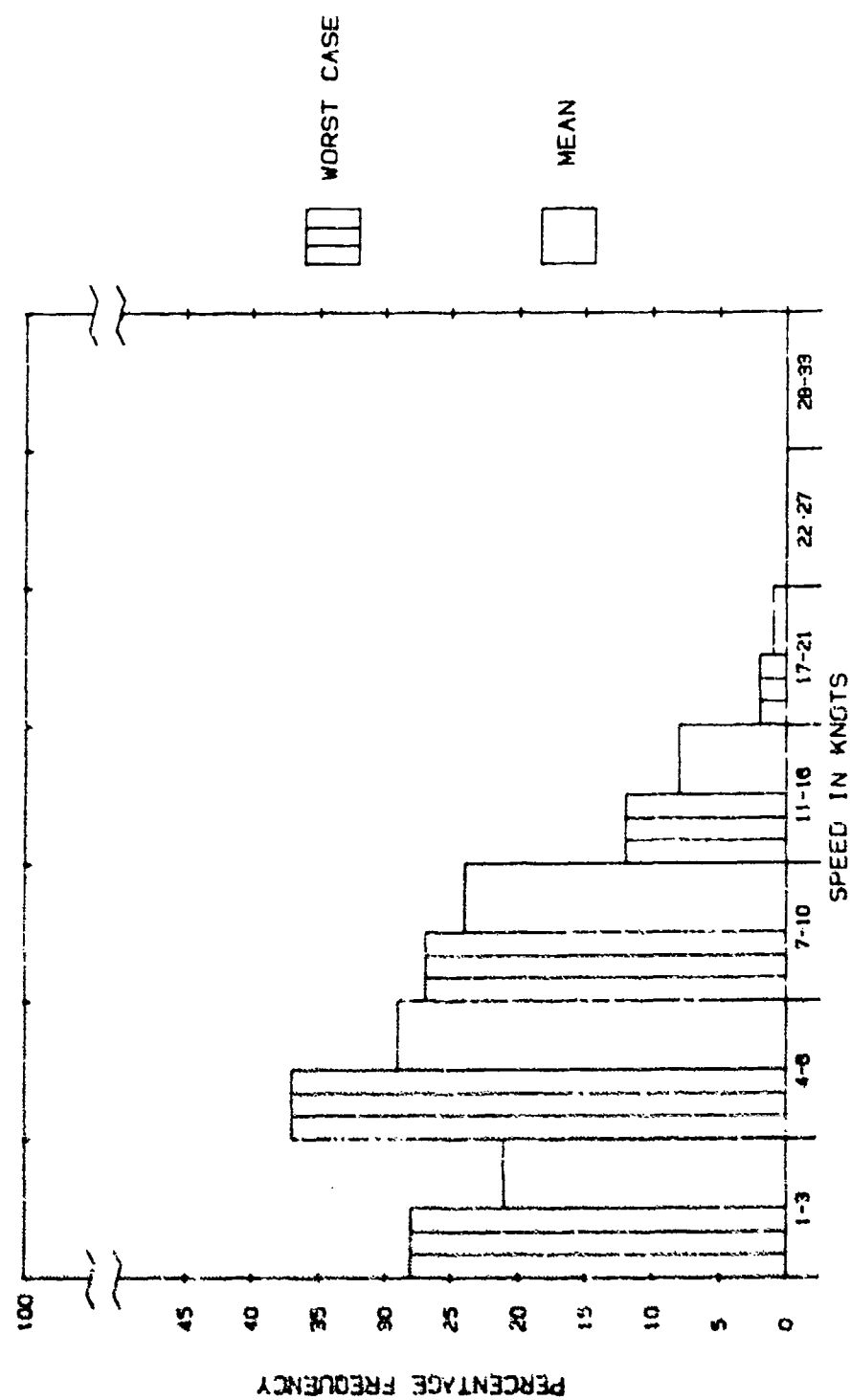


Figure A-240. Frequency of Occurrence of Wind Speeds, Germany in July.

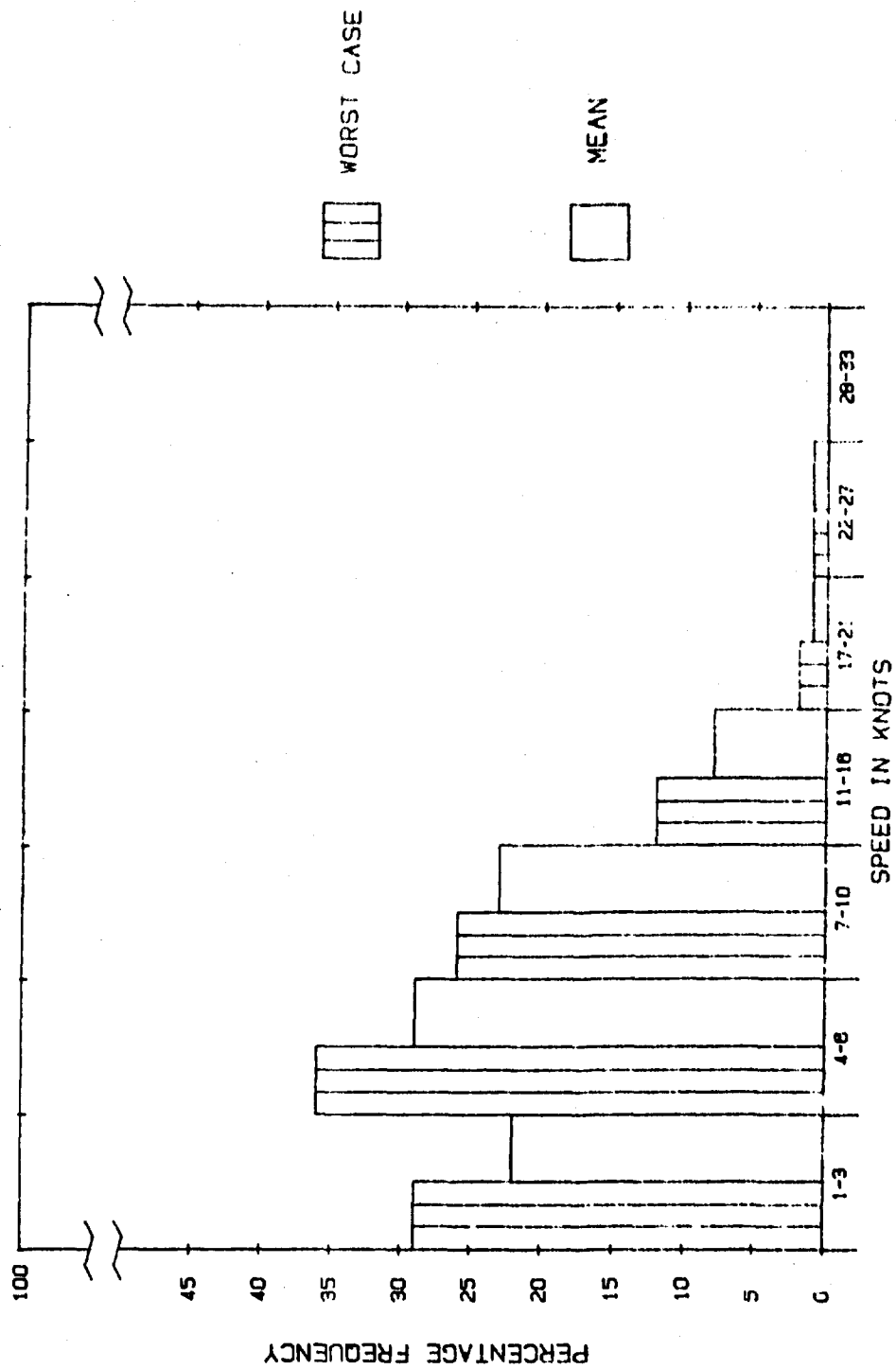


Figure A-241. Frequency of Occurrence of Wind Speeds, Germany in August.

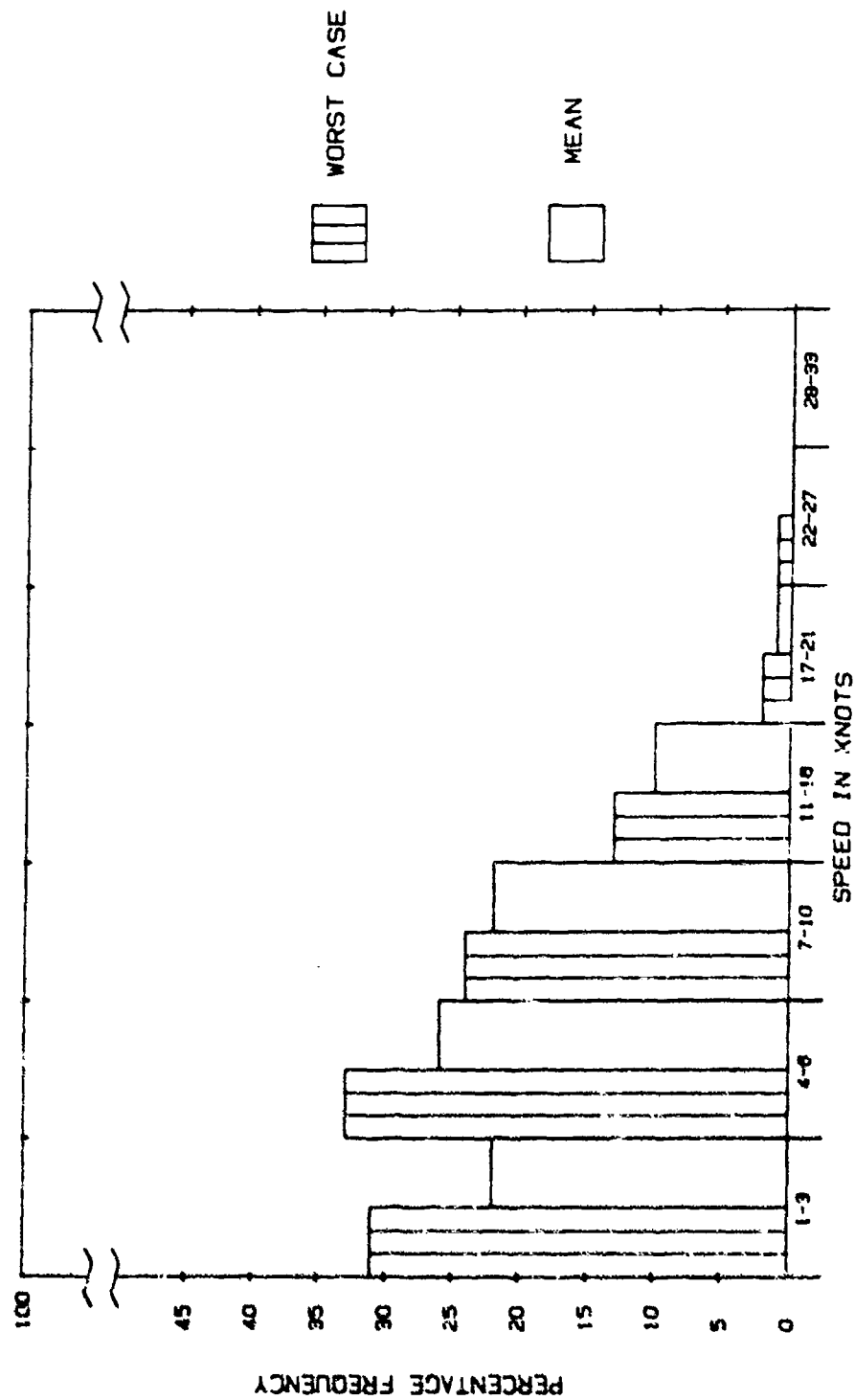


Figure A-242. Frequency of Occurrence of Wind Speeds, Germany in September.

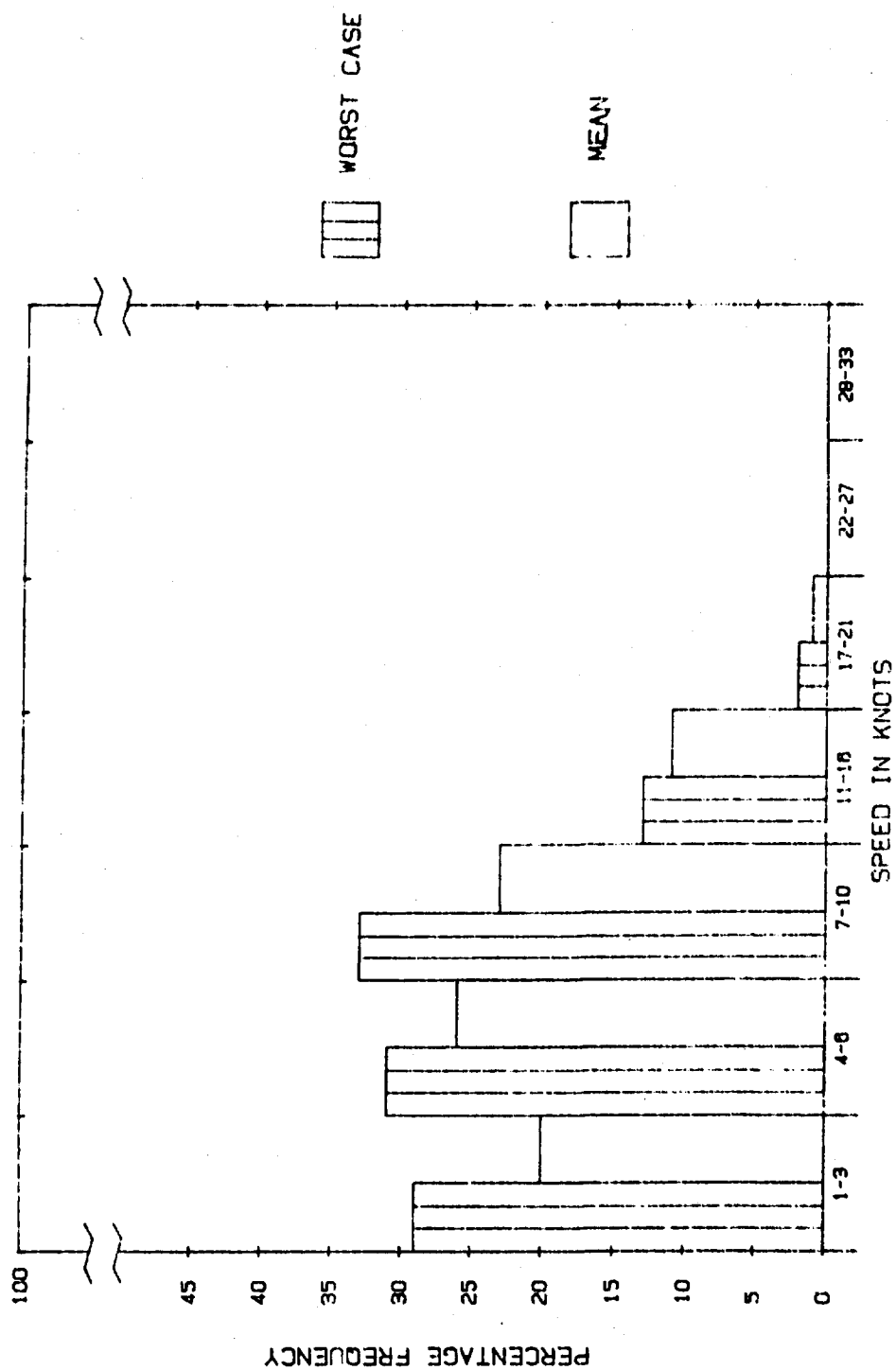


Figure A-243. Frequency of Occurrence of Wind Speeds, Germany in October.

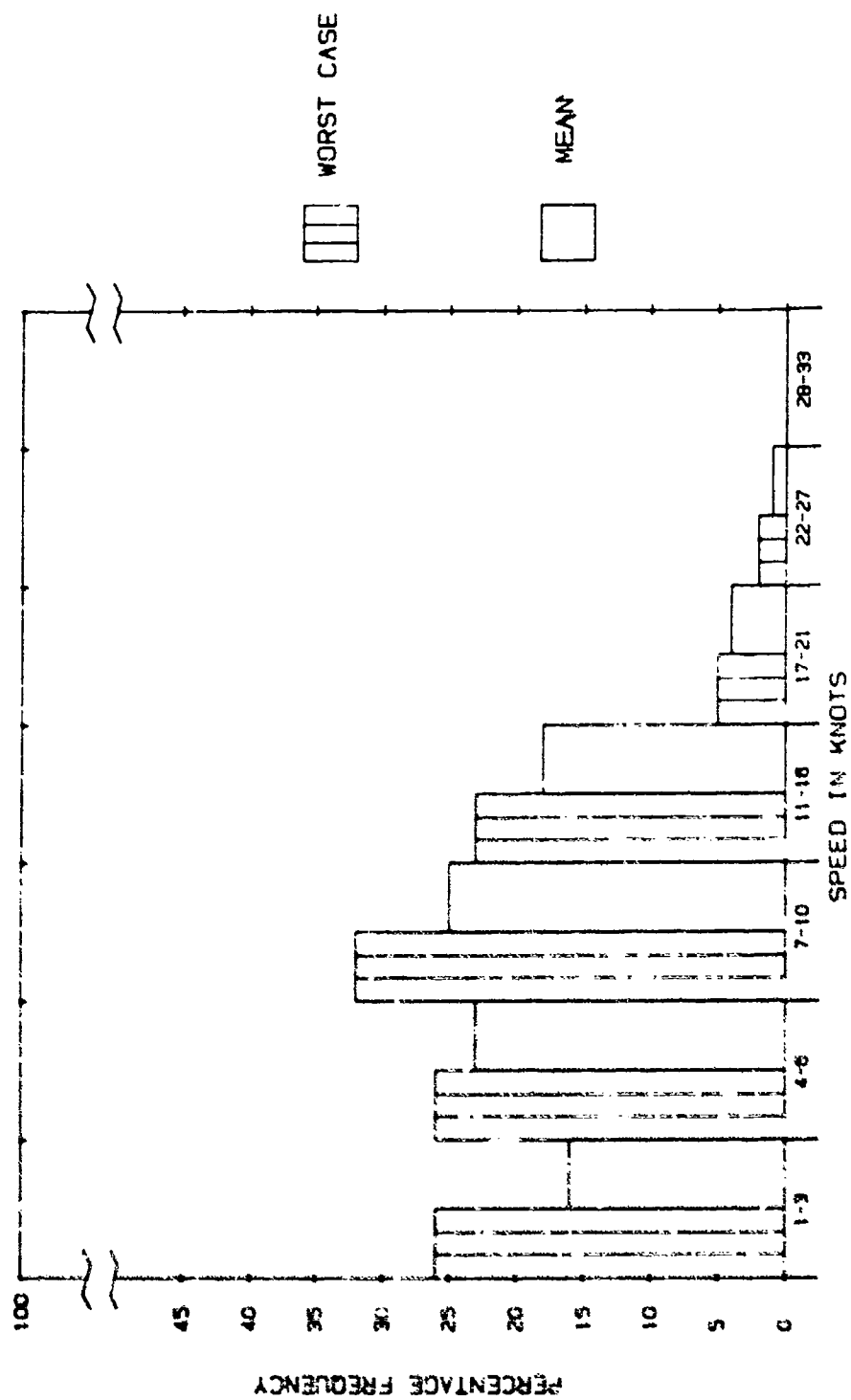


Figure A-244. Frequency of Occurrence of Wind Speeds, Germany in November.

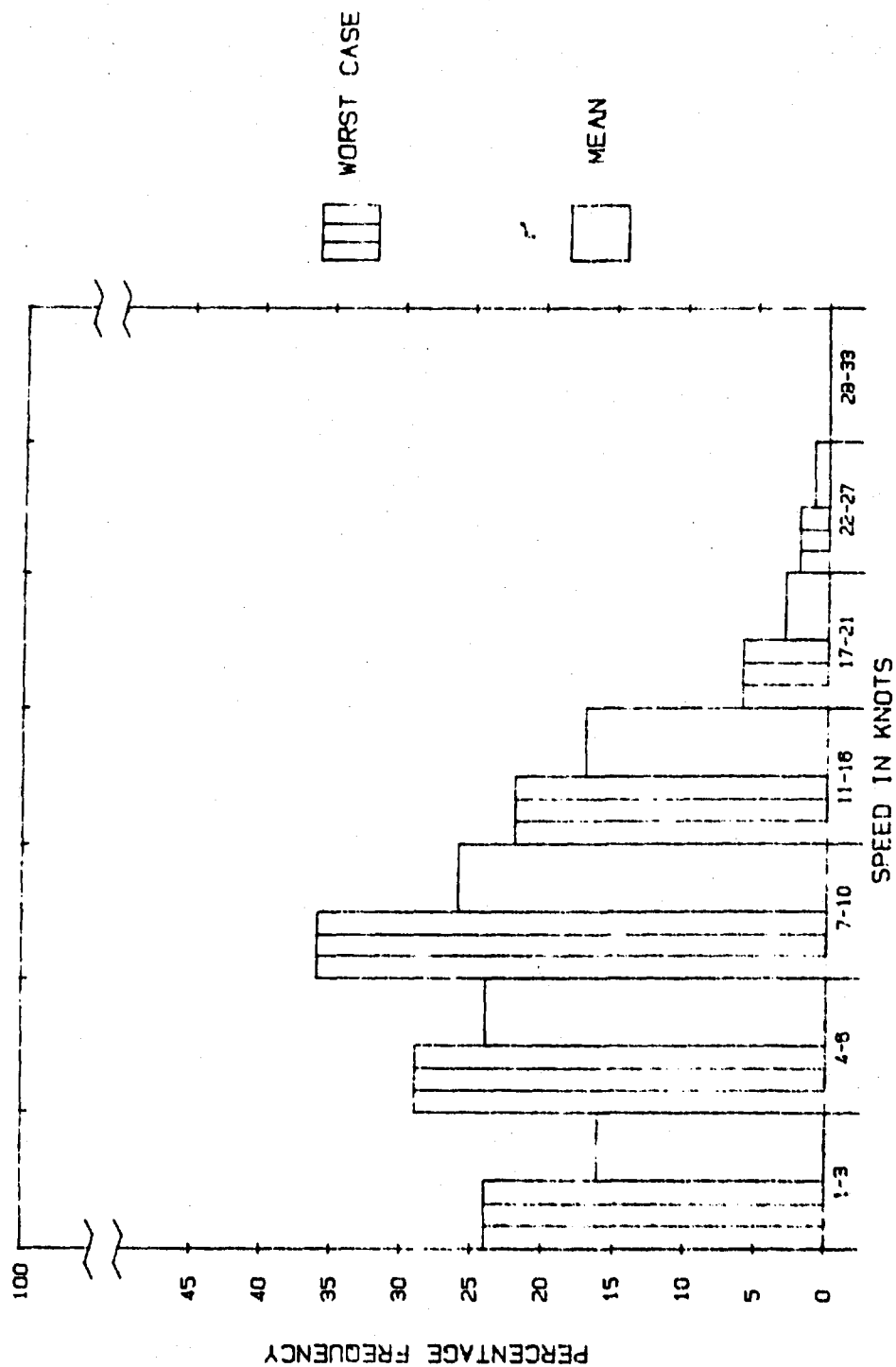


Figure A-245. Frequency of Occurrence of Wind Speeds, Germany in December.

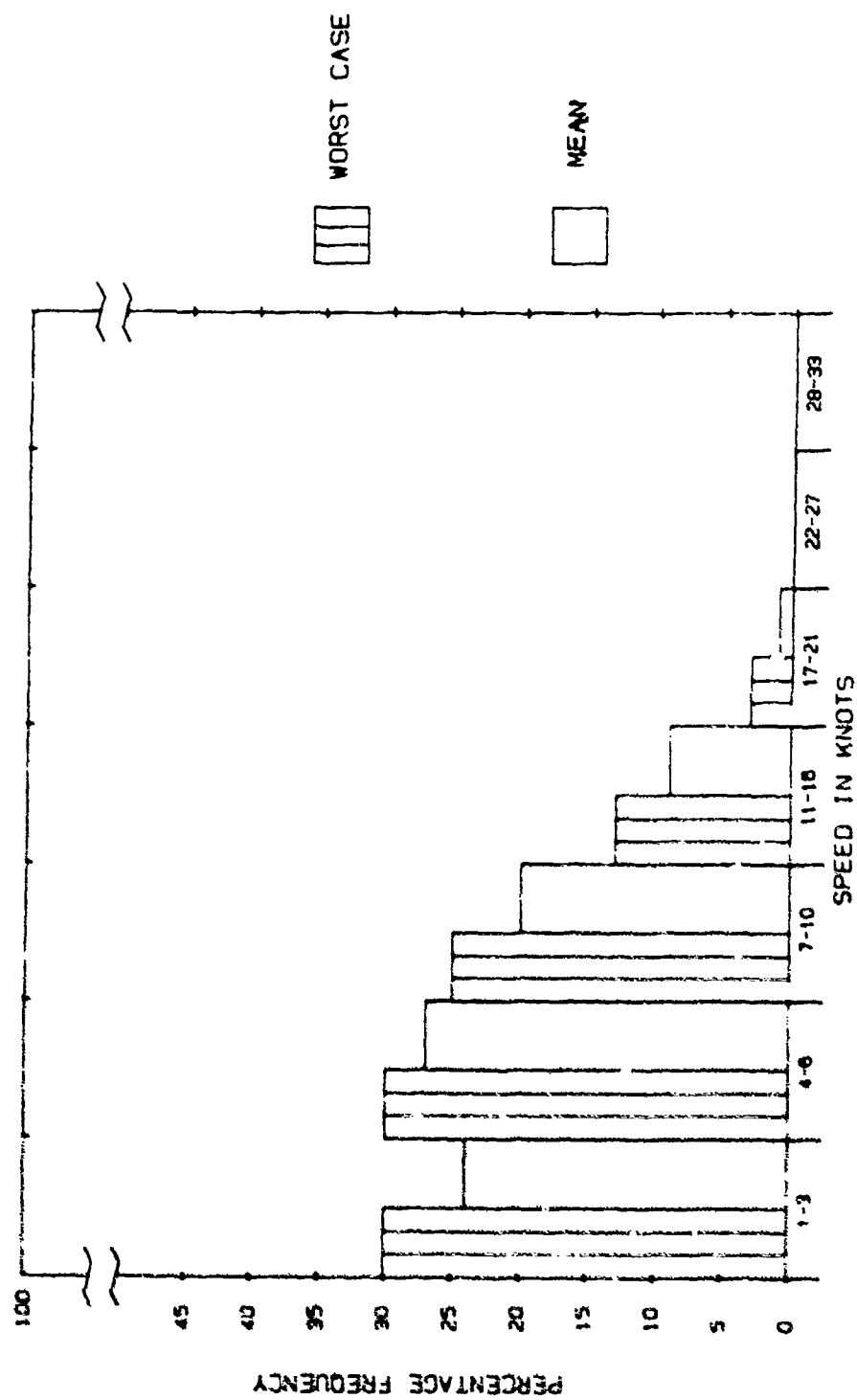


Figure A-246. Annual Frequency of Occurrence of Wind Speeds, Korea.

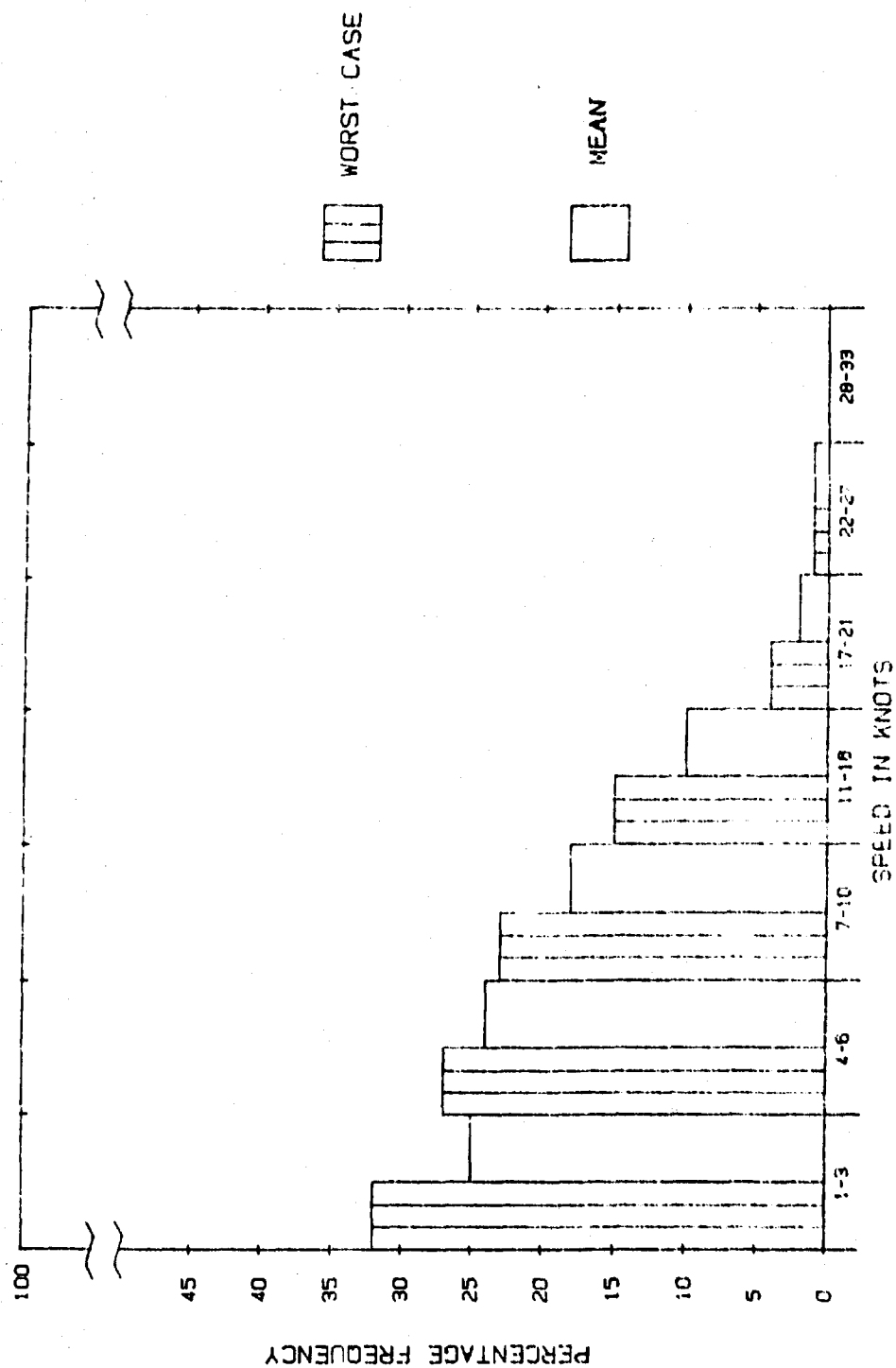


Figure A-2A7. Frequency of Occurrence of Wind Speeds, Korea in January.

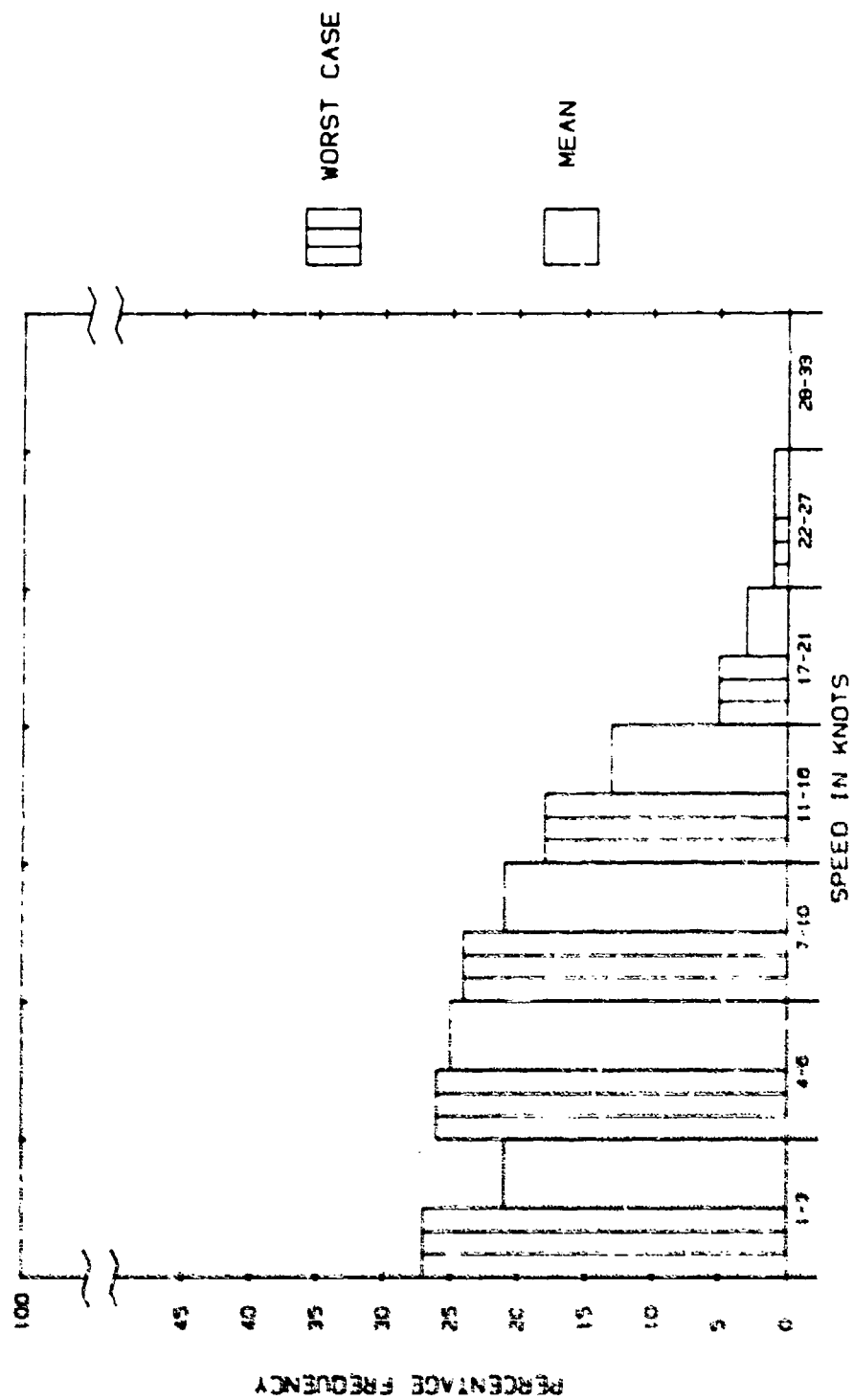


Figure A-248. Frequency of Occurrence of Wind Speeds, Korea in February.

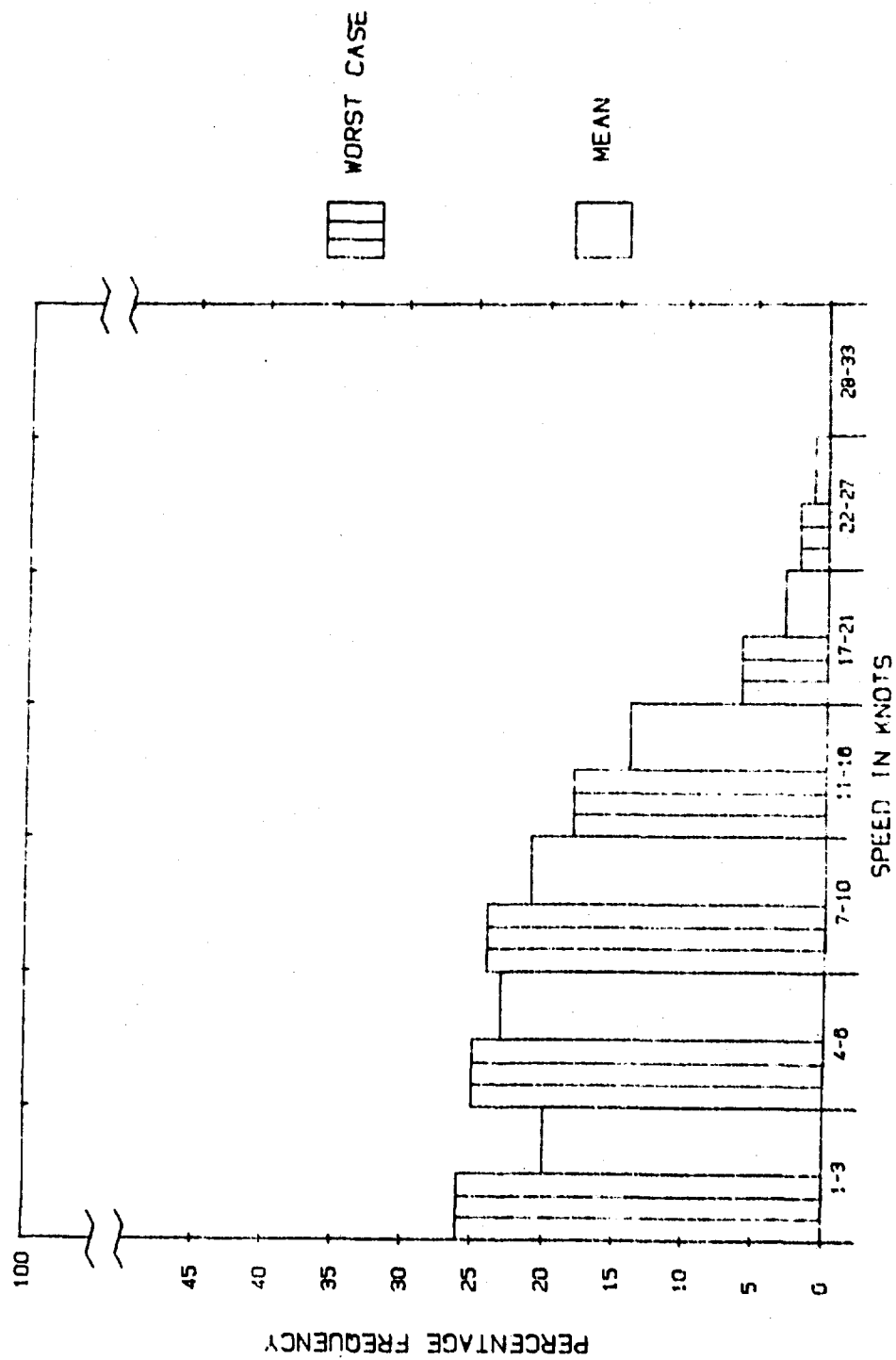


Figure A-249. Frequency of Occurrence of Wind Speeds, Korea in March.

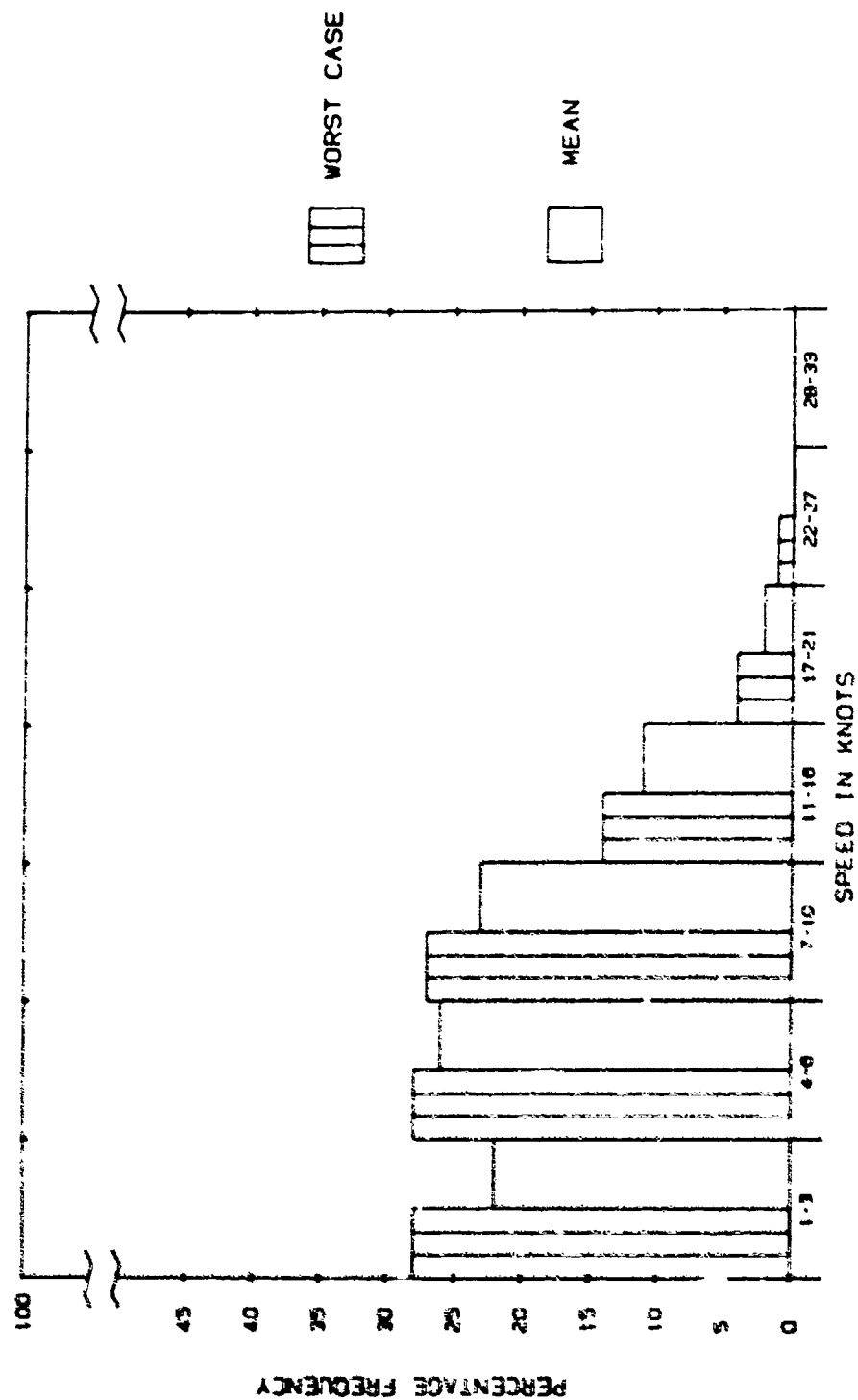


Figure A-250. Frequency of Occurrence of Wind Speeds, Korea in April.

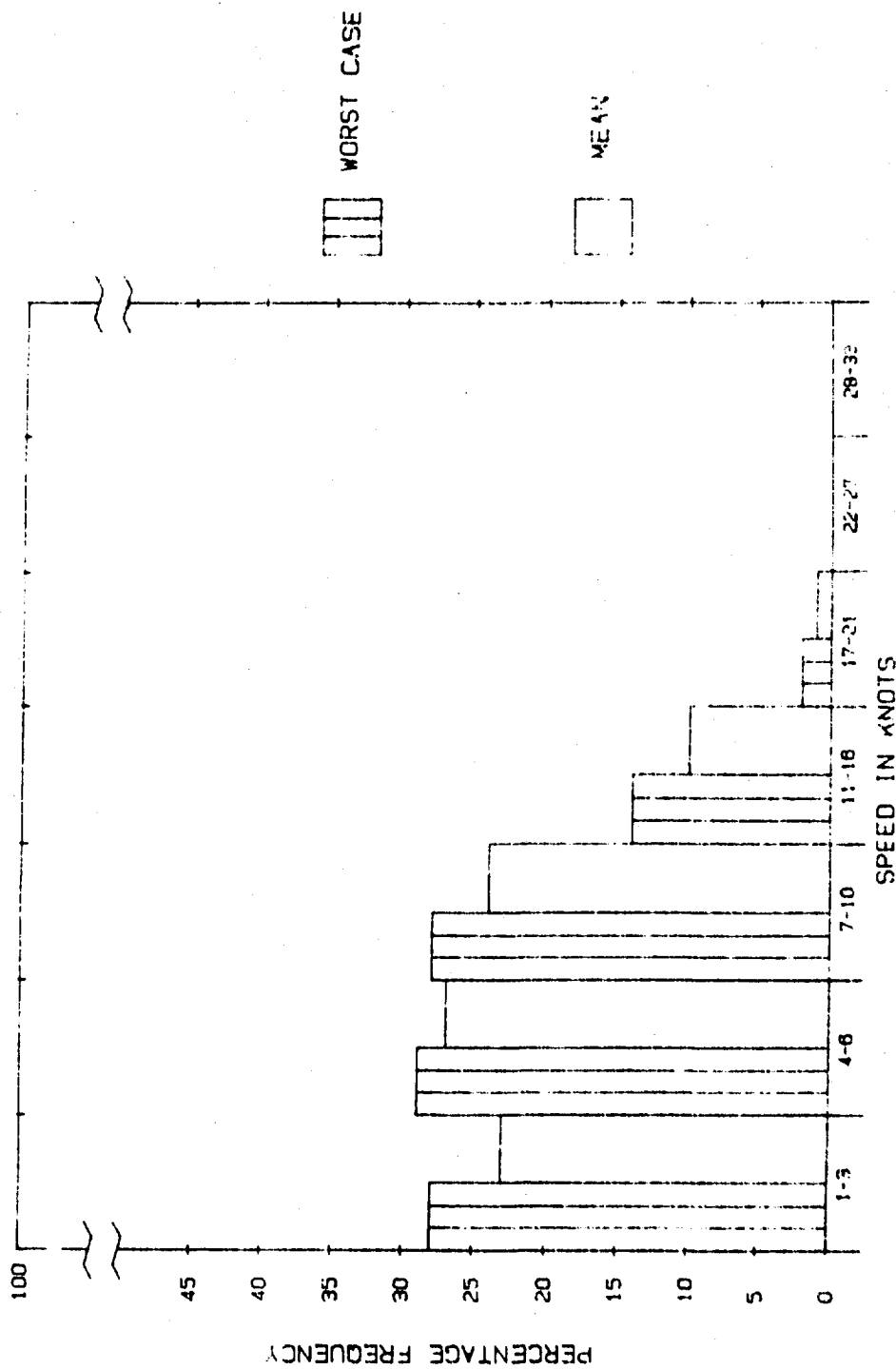


Figure A-251. Frequency of Occurrence of Wind Speeds, Korea in May.

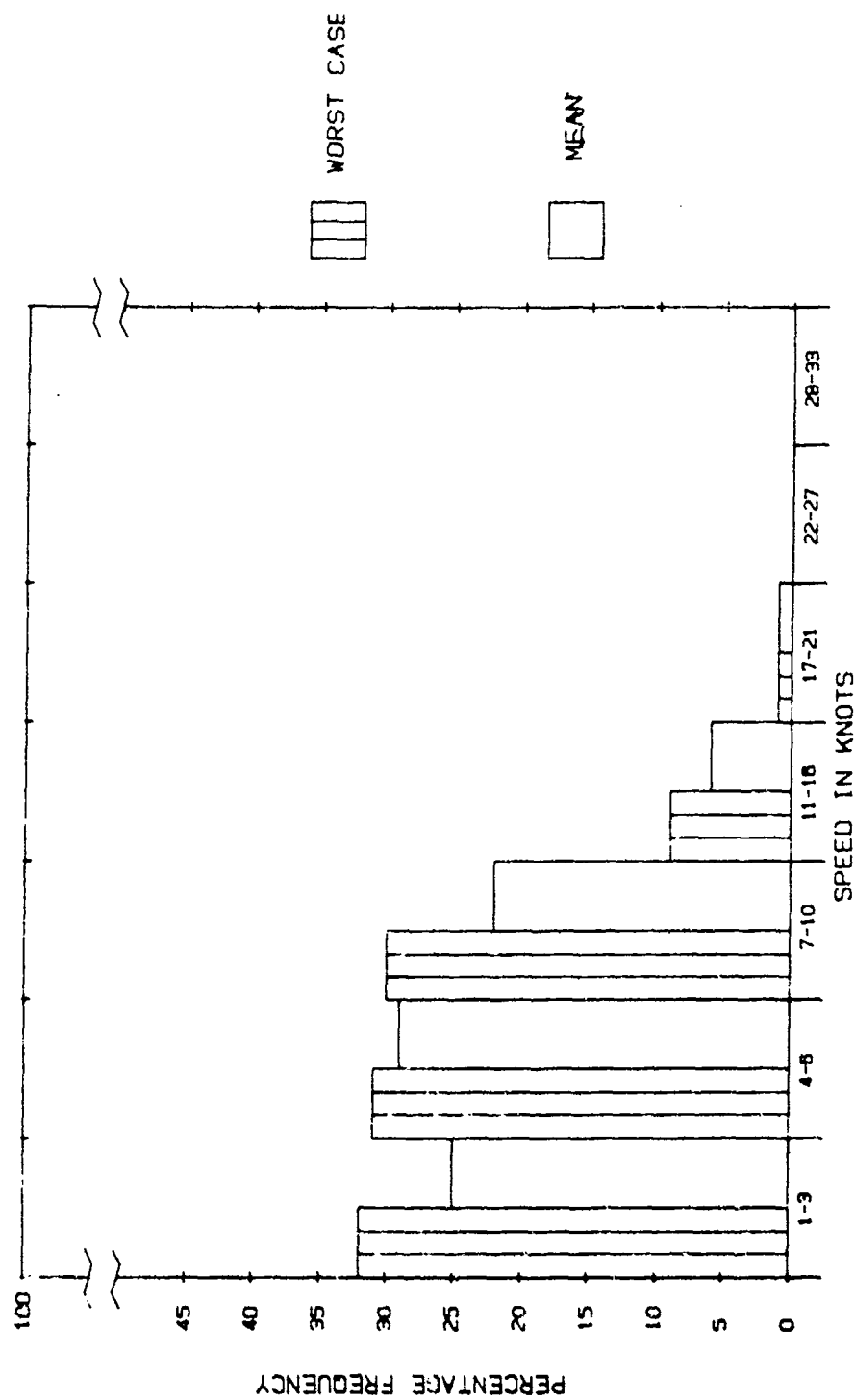


Figure A-252. Frequency of Occurrence of Wind Speeds, Korea in June.

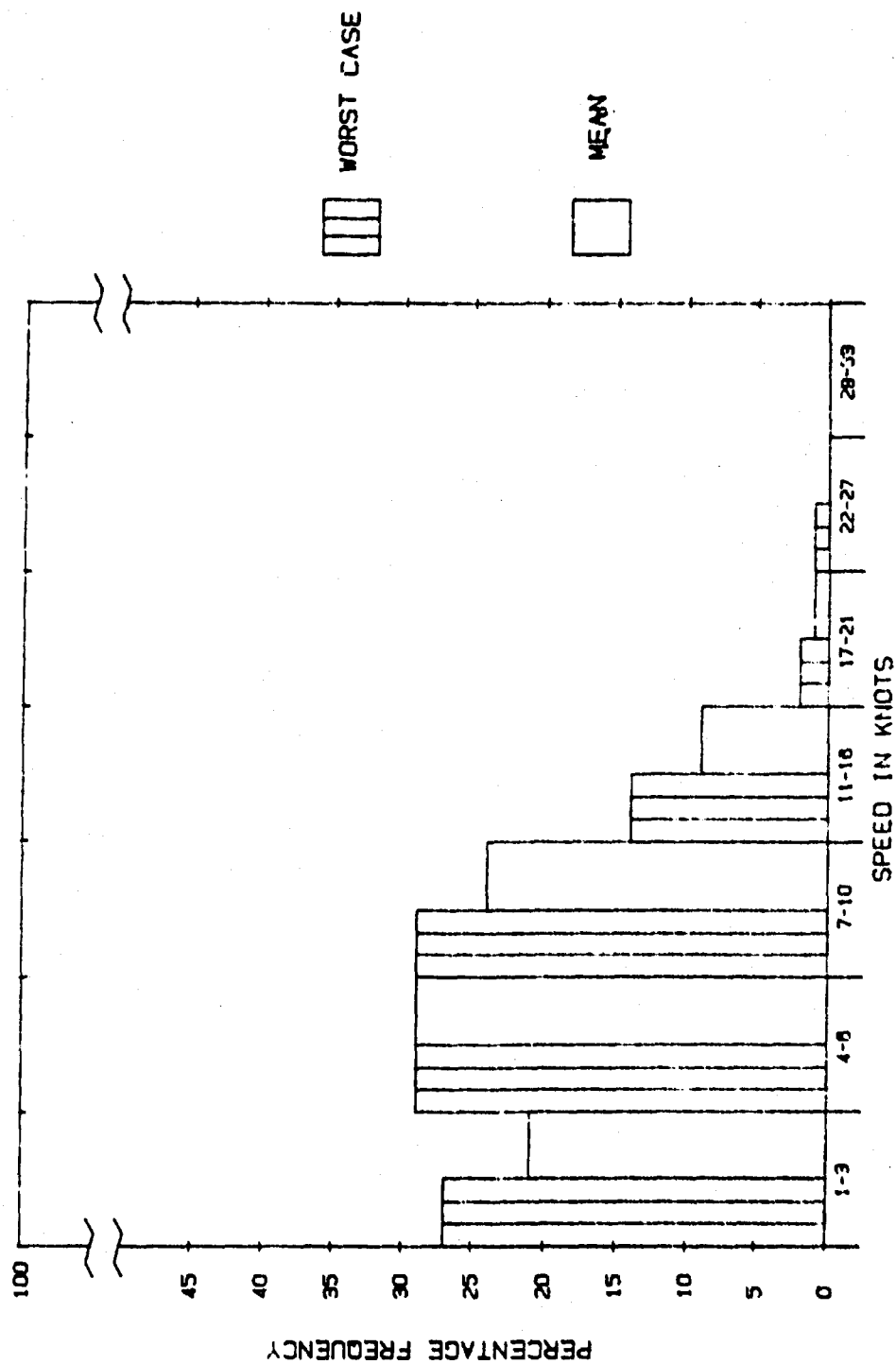


Figure A-253. Frequency of Occurrence of Wind Speeds, Korea in July.

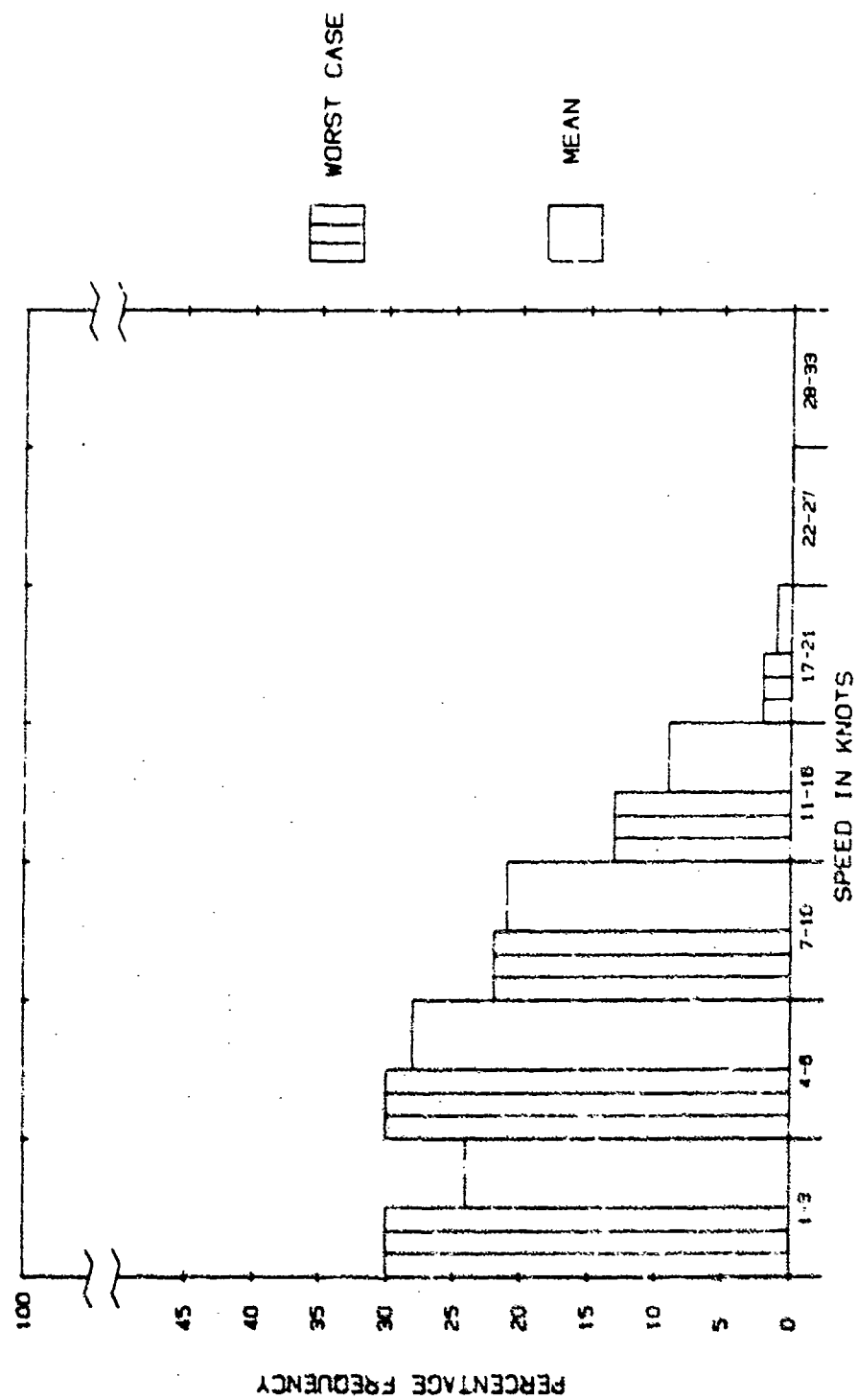


Figure A-254. Frequency of Occurrence of Wind Speeds, Korea in August.

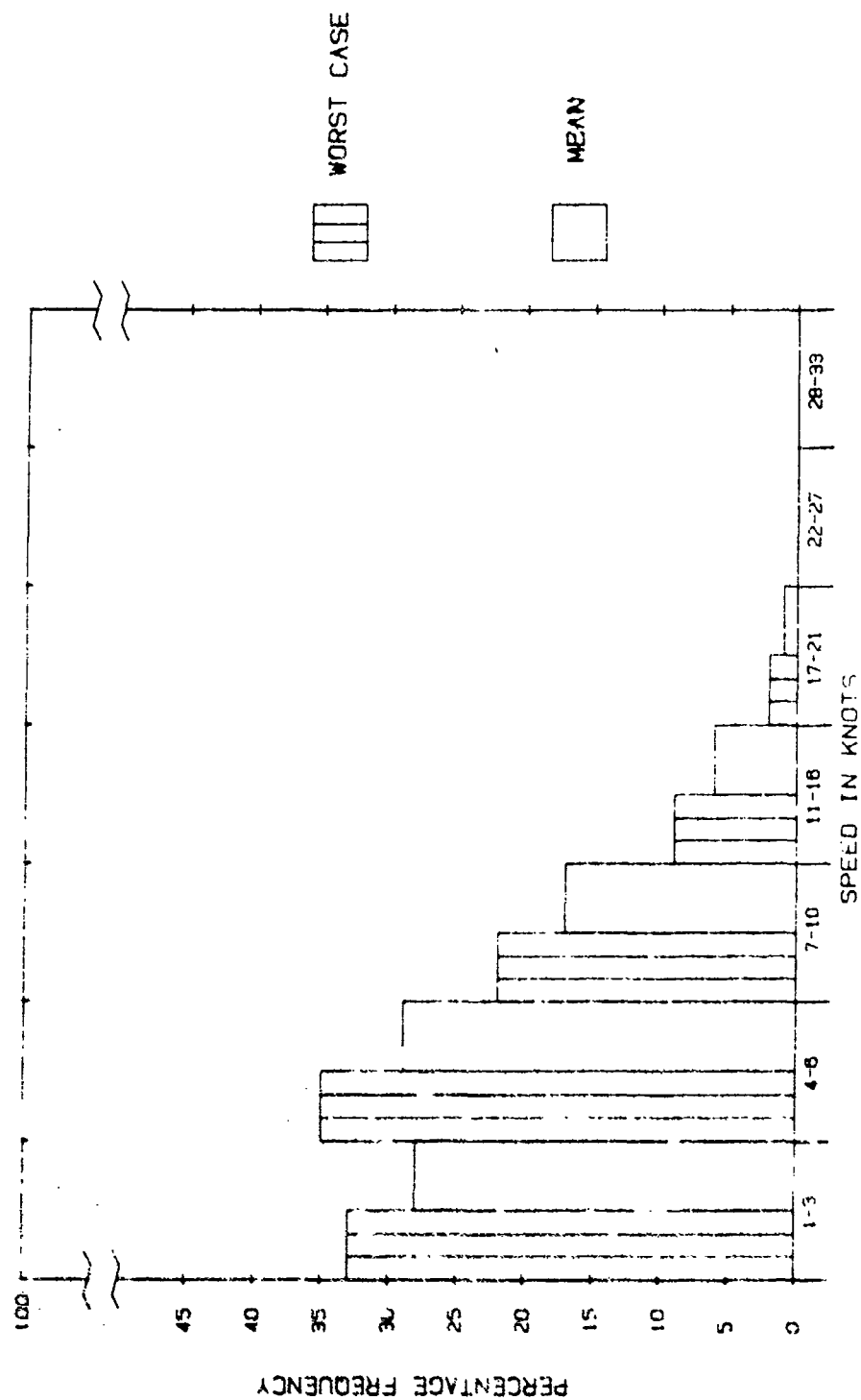


Figure A-255. Frequency of Occurrence of Wind Speeds, Korea in September.

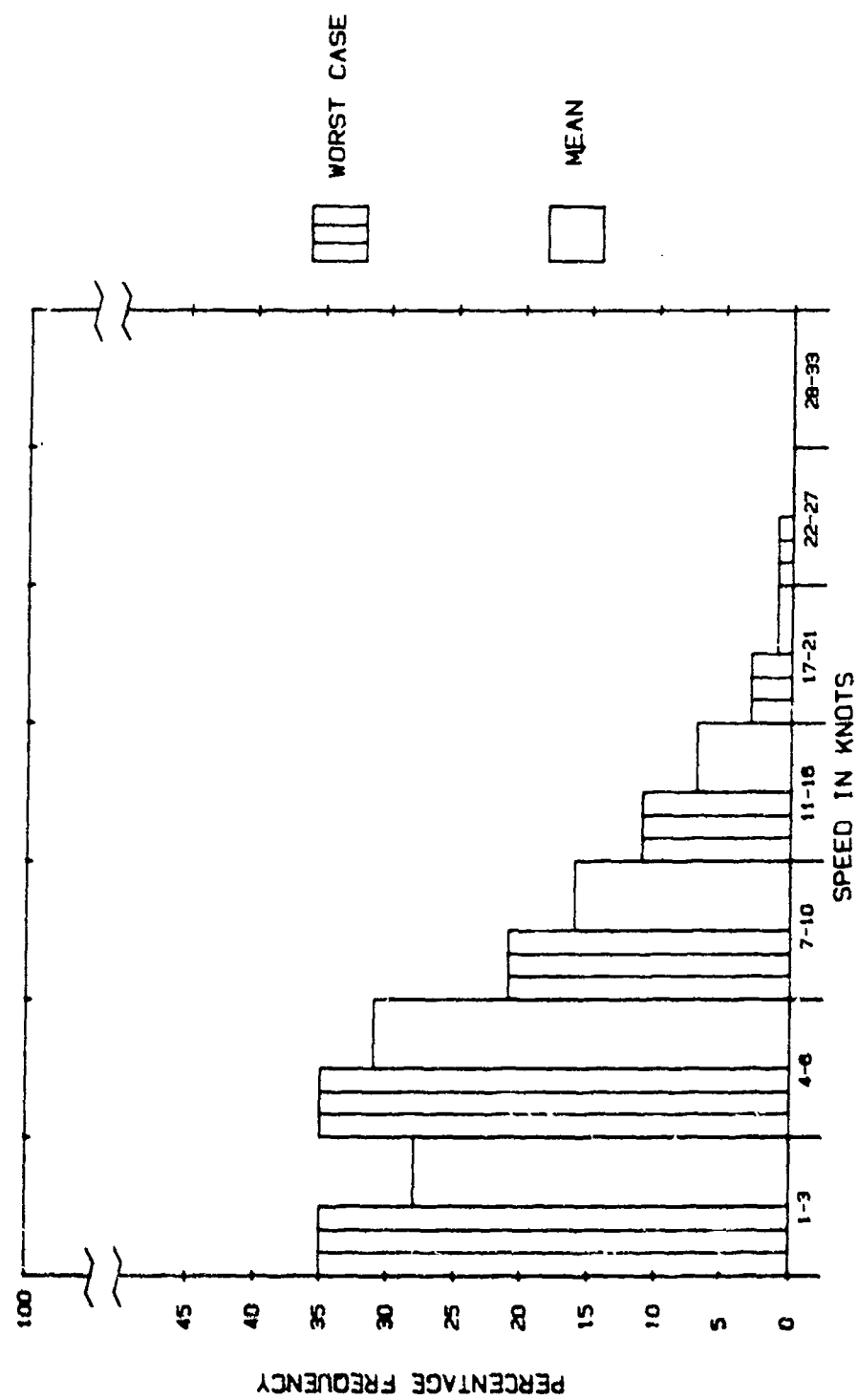


Figure A-256. Frequency of Occurrence of Wind Speeds, Korea in October.

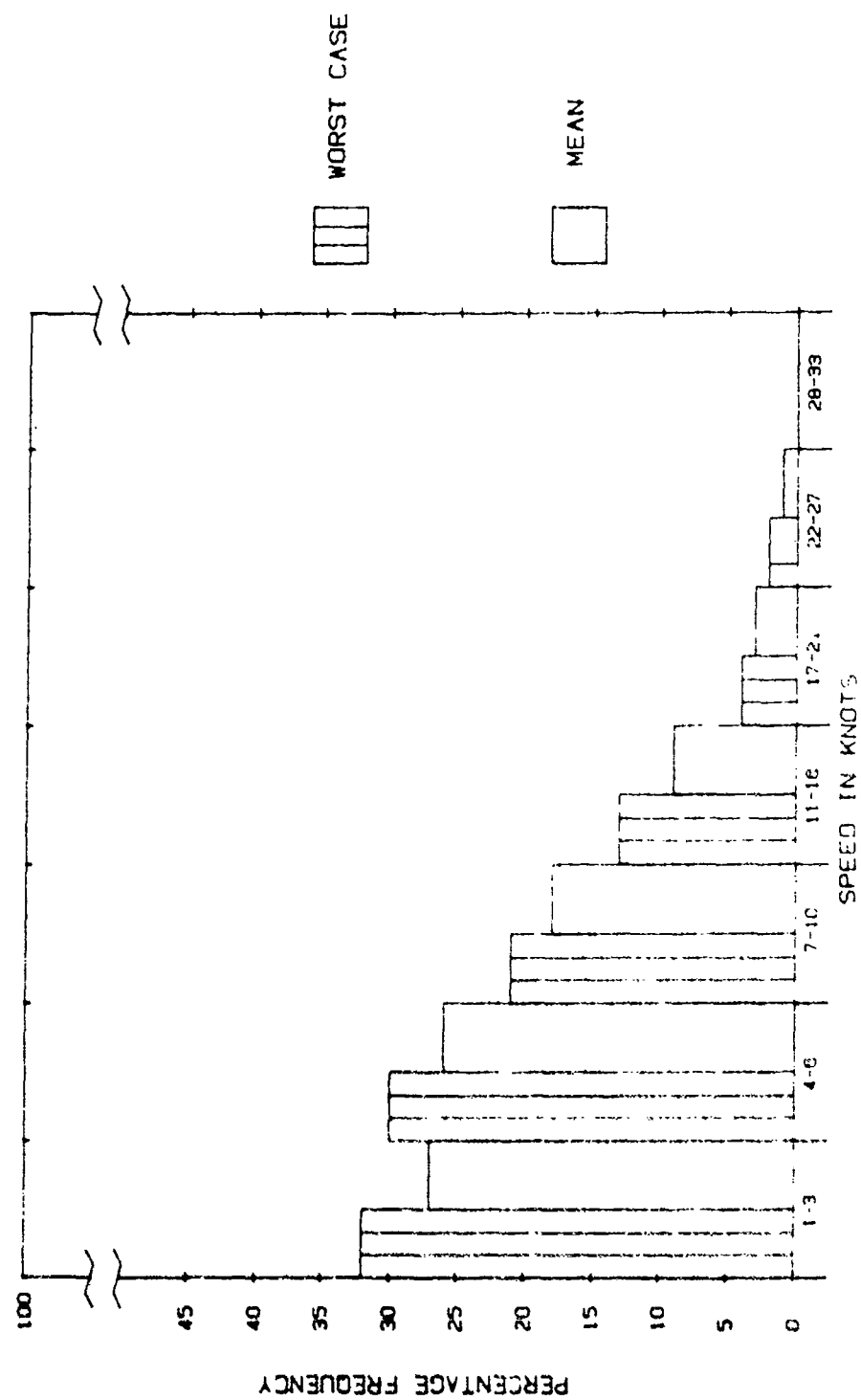


Figure A-257. Frequency of Occurrence of Wind Speeds, Korea in November.

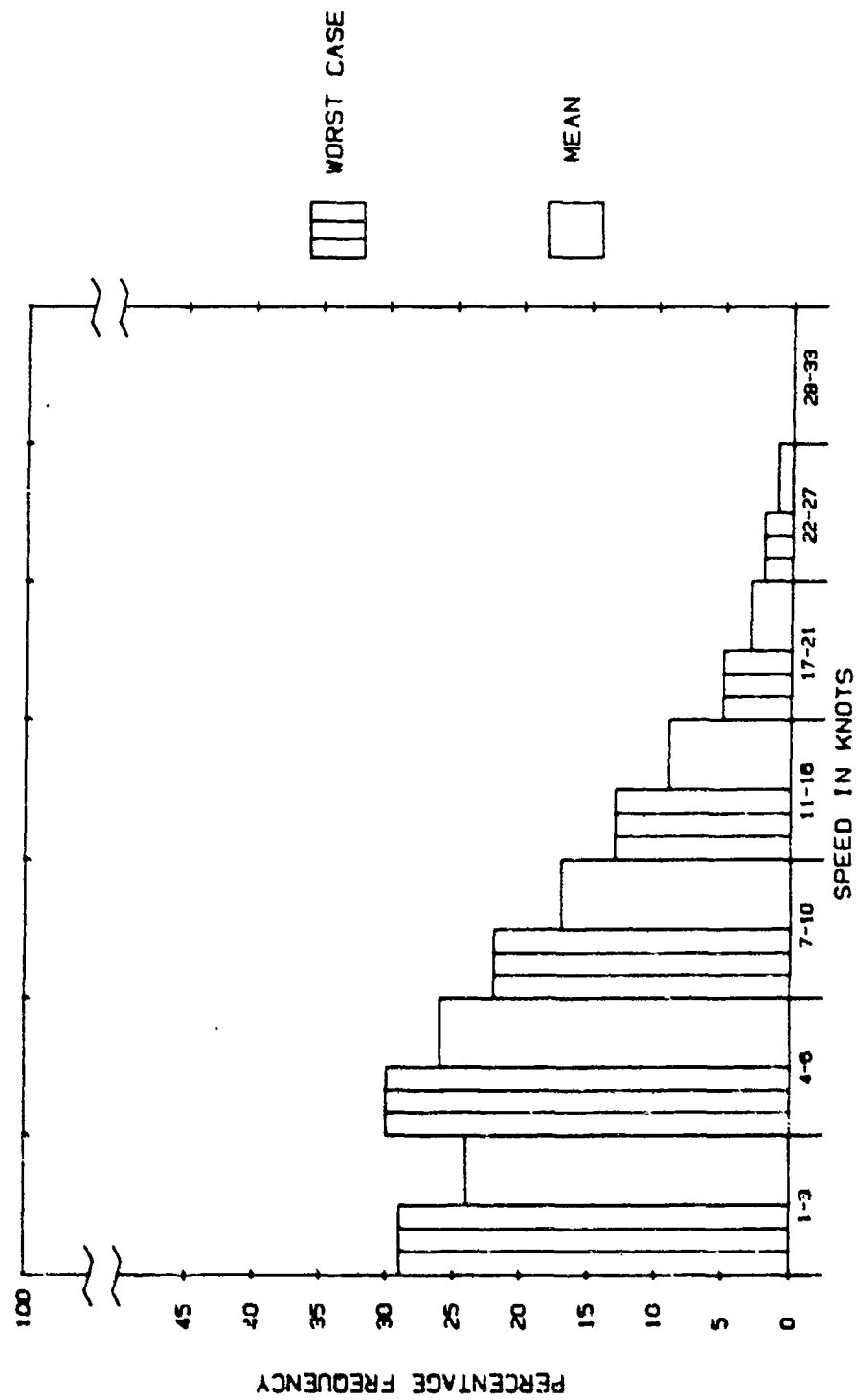


Figure A-258. Frequency of Occurrence of Wind Speeds, Korea in December.

5. RELATIVE HUMIDITY

Relative humidity becomes especially important when measured in conjunction with temperature. The National Weather Service has developed a Discomfort Index which is a function of relative humidity and ambient temperature. It is

$$DI = DB - (.55 - .55RH) \times (DB - 58)$$

where DI = Discomfort Index
 DB = Dry Bulb Temperature
 RH = Relative Humidity Expressed as a Decimal

Then to find the temperature which would give the same discomfort index with 70 percent relative humidity (a somewhat arbitrarily chosen, comfortable, or average value), use

$$T_{.70} = .659 RH \times DB + .539 \times DB - 39.204 \times RH + 26.743$$

where $T_{.70}$ = equivalent temperature at 70 percent relative humidity.

In the example above, $T_{.70} = 96^{\circ}\text{F}$.

a. Mean Relative Humidity

For each airbase in a theater, the relative humidity was measured and recorded at hourly intervals. These data were grouped by month and averaged across the theater. The annual mean relative humidity was computed by averaging the mean relative humidity for each airbase over the 12 months. The worst case for this weather condition was ill defined since worst occurrences can be either high or low humidity, dependent upon the temperature. Thus, worst-case data is omitted.

EXAMPLE: In Figure A-259, the mean relative humidity at Upper Heyford in July is approximately 72 percent. The annual mean relative humidity, calculated by averaging each of the annual mean values over all the years of observation, is approximately 78 percent.

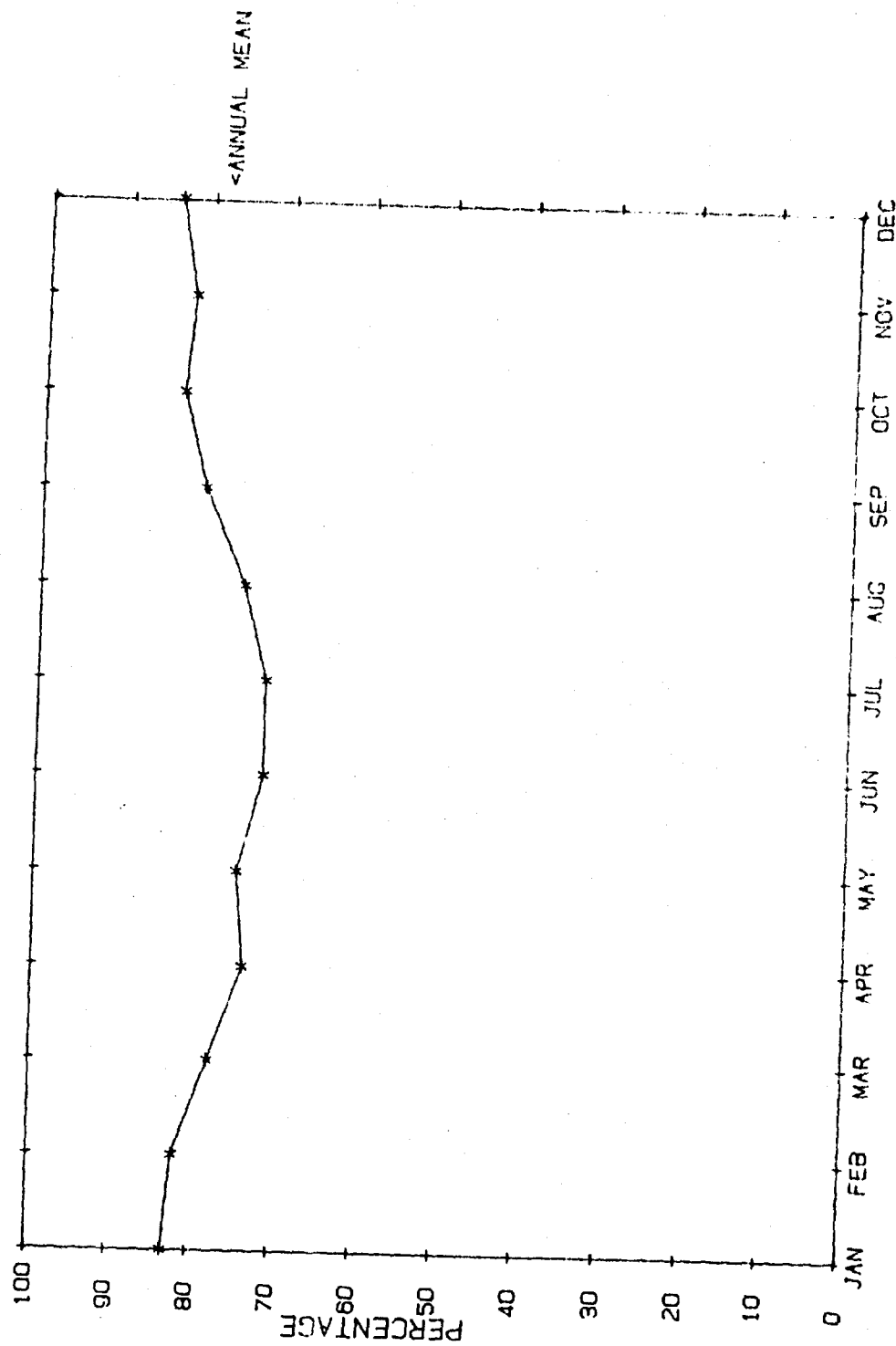


Figure A-259. Mean Relative Humidity, Upper Heyford.

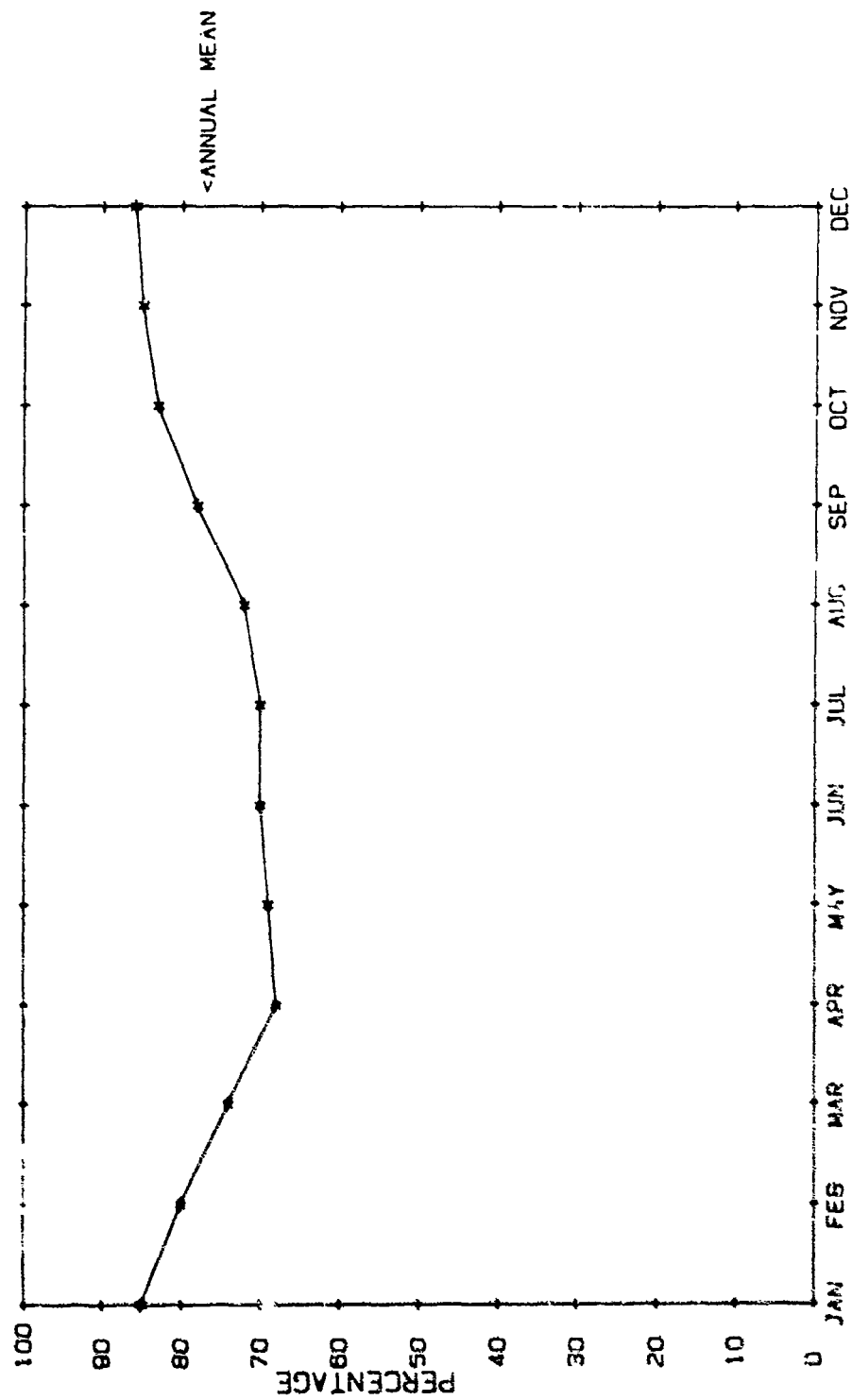


Figure A-260. Mean Relative Humidity, Mean of German Airbases.

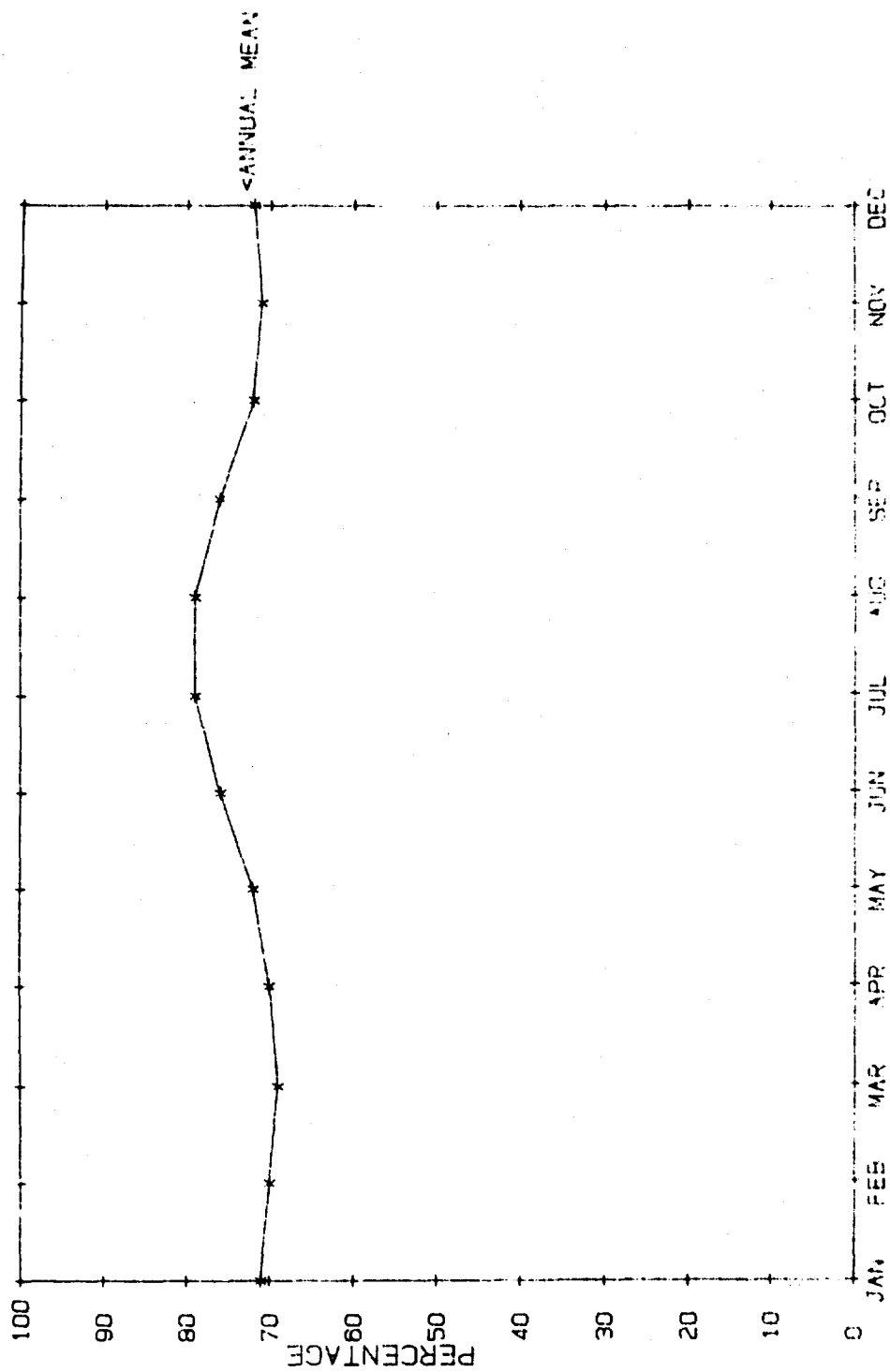


Figure A-261. Mean Relative Humidity, Mean of Korean Airbases.

b. Ranges of Relative Humidity

For each airbase in a theater, relative humidity was recorded at hourly intervals. The data were then averaged across each year. These statistics were computed by determining the percentage of those observations that were within each humidity range indicated on the graphs. These probabilities were then averaged across the theater.

EXAMPLE: From Figure A-262, 25 percent of all the recorded relative humidities at Upper Heyford ranged from 70 to 80 percent.

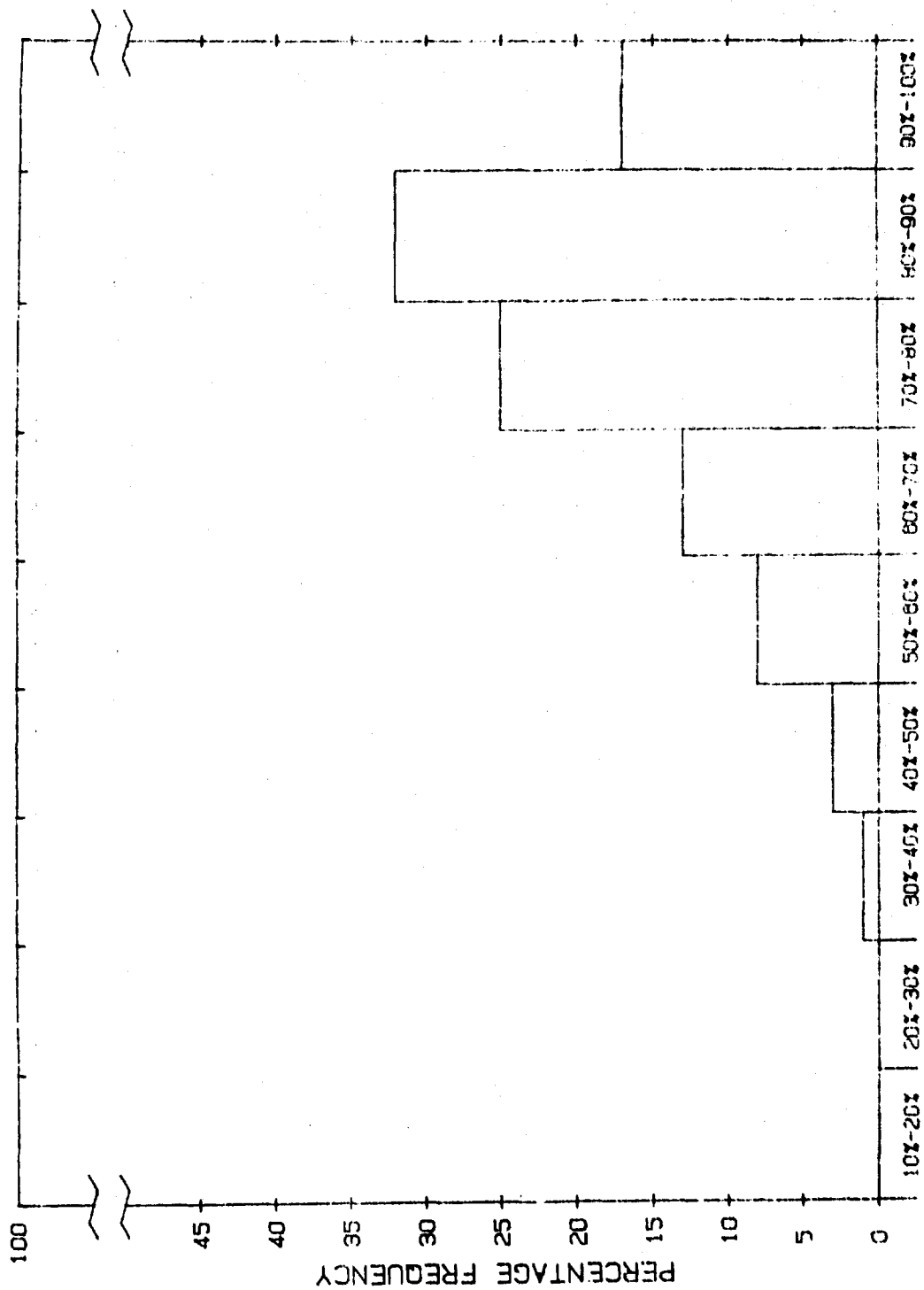


Figure A-262. Ranges of Relative Humidity. Upper Heyford - Annual.

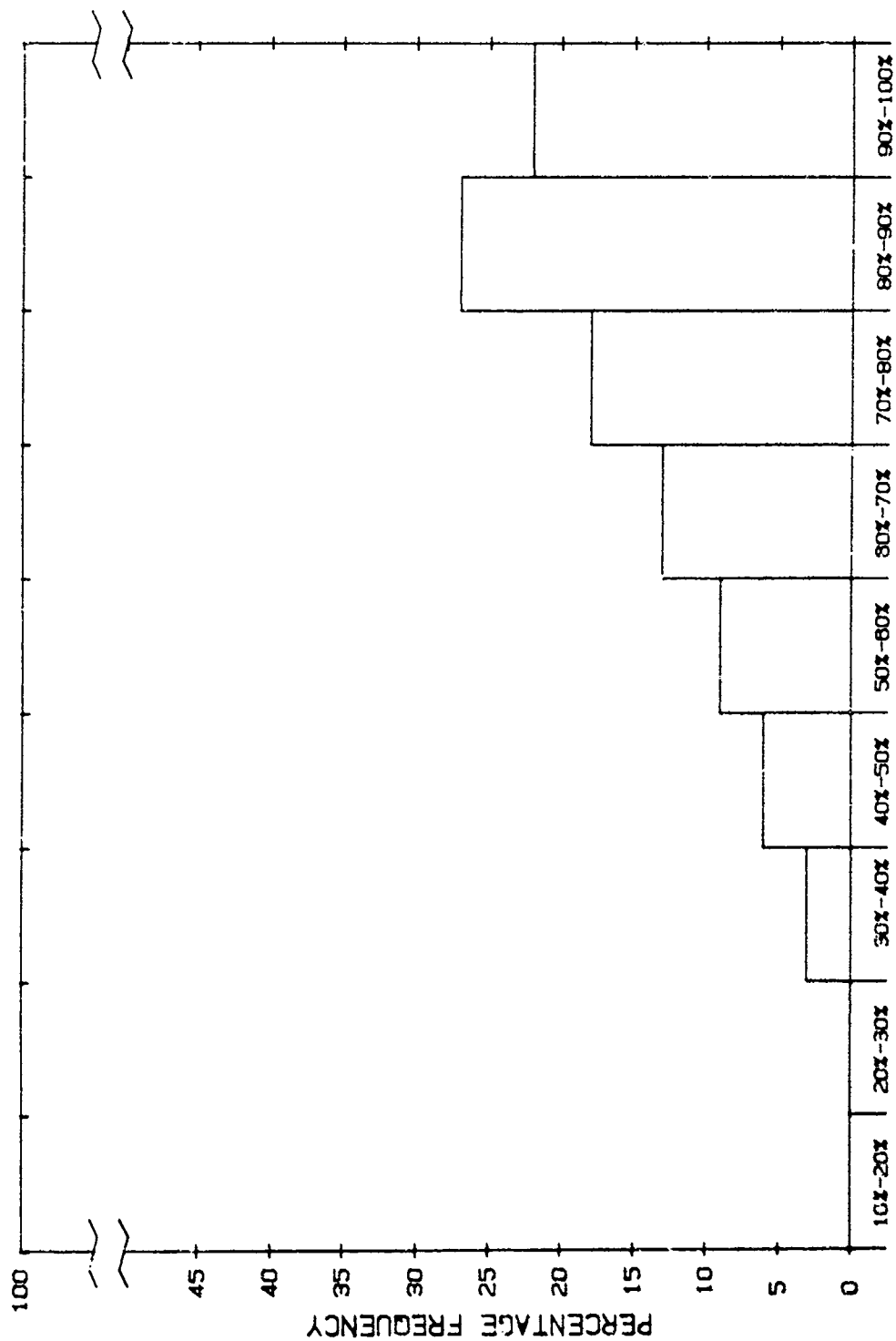


Figure A-263. Ranges of Relative Humidity, Mean of German Airbases - Annual.

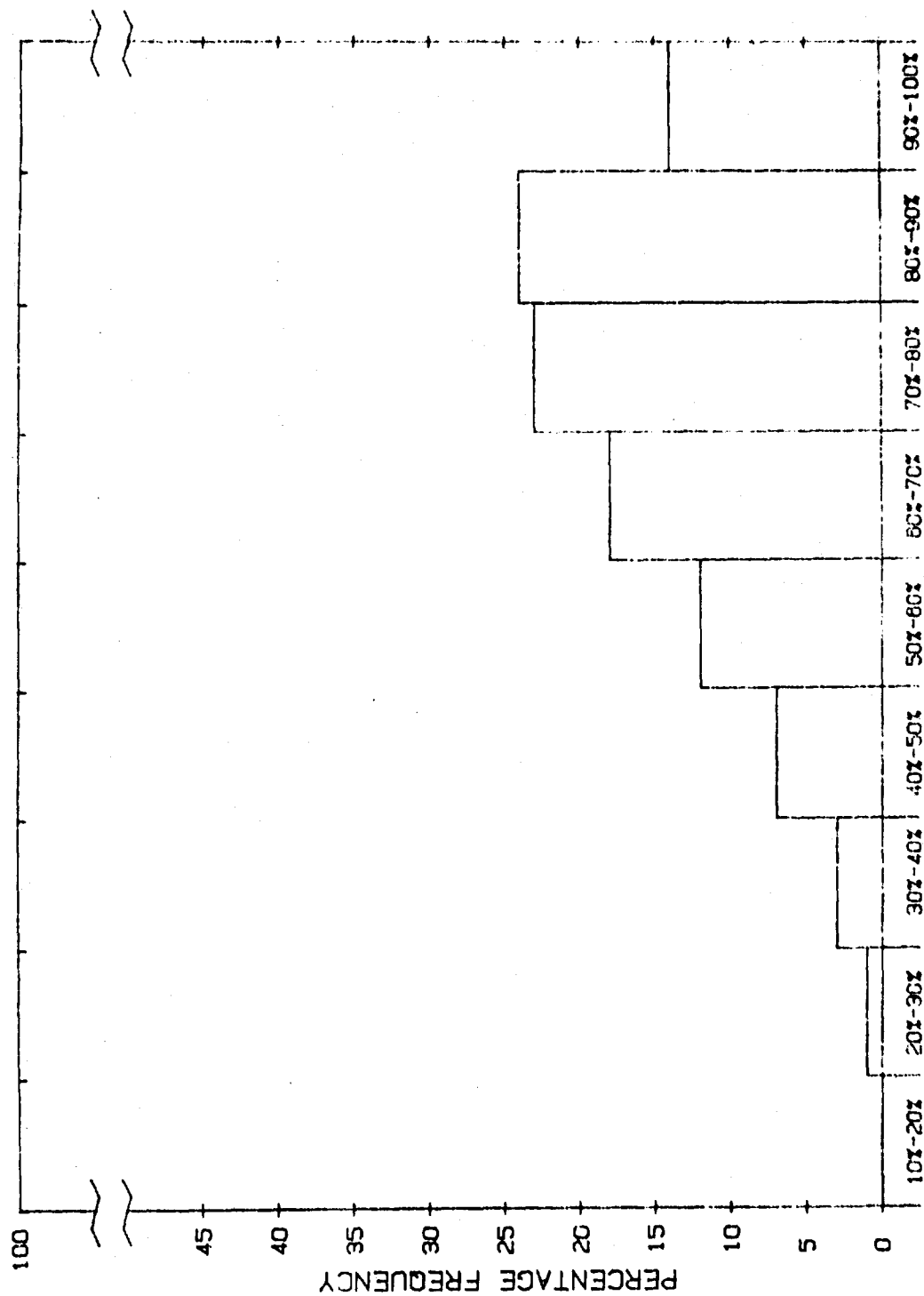


Figure A-26: Ranges of Relative Humidity, Mean of Korean Airbases - Annual.

REFERENCES

- 1 Headquarters, Department of the Army and the Air Force, Air Force Manual No. 88-5, Chapter 1, Surface Drainage Facilities for Airfields and Heliports, Washington, D.C., 1 April 1977.